Vol. 14 No 1

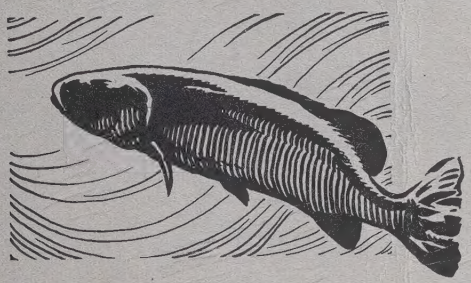
LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

FEB 19 1952

VOL. 14 No. 1 JANUARY 1952

THE

Progressive Fish-Culturist



UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary

FISH AND WILDLIFE SERVICE
Albert M. Day, Director

The Progressive Fish-Culturist

Editors
A. V. Tunison, Branch of Game-fish and Hatcheries, Fish and Wildlife Service
W. F. Carbine, Branch of Fishery Biology, Fish and Wildlife Service

Associate Editors
Dr. Kenneth D. Carlander, Department of Zoology and Entomology, Iowa State College, Ames, Iowa
Minor E. Clark, Superintendent of Fisheries, Division of Game and Fish, Frankfort, Kentucky
Clarence F. Pautzke, Chief, Fishery Management Division, Department of Game, Seattle, Washington
Lyle M. Thorpe, Chief, Fisheries Management, State Board of Fisheries and Game, Hartford, Connecticut
Marion Toole, Chief Aquatic Biologist, Game and Fish Commission, Austin, Texas

Assistant Editor
Sylvia M. Mullin, Branch of Game-fish and Hatcheries, Fish and Wildlife Service

Contributions for publication in THE PROGRESSIVE FISH-CULTURIST are always welcome. Good illustrations (in the form of glossy prints) add considerably to the value of most papers. Manuscripts and correspondence should be directed to the Editors, THE PROGRESSIVE FISH-CULTURIST, Fish and Wildlife Service, Interior Building, Washington 25, D. C.

The publication herein in whole or in part of material selected from sources outside the Fish and Wildlife Service is not to be construed as an endorsement thereof, nor is the Fish and Wildlife responsible for the correctness of statements of fact, views, or opinions found in such material. Similarly, the Fish and Wildlife Service makes neither recommendation nor endorsement of any commercial product, nor has it made any determination with respect to patent rights that may be involved in devices, etc., mentioned in this publication.

The contents of this publication have not been copyrighted and may be reprinted freely, but reference to the source will be appreciated.

The printing of this publication has been approved by the Director of the Bureau of the Budget, May 21, 1951.

UNITED STATES GOVERNMENT PRINTING OFFICE . WASHINGTON : 1952

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.
Price

THE

Progressive Fish-Culturist

A Quarterly for Fishery Biologists and Fish-Culturists

Volume 14 | Washington, D. C. | January 1952 | Number 1

TABLE OF CONTENTS

Page

The Use of Torula Yeast in the Feeding of Trout
-- W. S. Churchill 3

An Interim Report on Gill Disease
-- R. R. Rucker, H. E. Johnson, and G. M. Kaydas 10

A Comparison of the Growth of Lake Trout Fingerlings From Eggs Taken in Seneca, Saranac, and Raquette Lakes
-- D. C. Haskell 15

The Effects of Supplemental Fats in the Diet of Brook Trout
-- A. M. Phillips, Jr.; D. R. Brockway; and J. M. Maxwell 19

A Method of Calculating Fish Production in Rearing Ponds
-- John Dobie 23

Suggestions for the Renovation of Fish Ponds
-- A. D. Holloway 27

A Preliminary Report on the Control of Fungus in the Eggs of the Pike (Esox lucius) With Malachite Green
-- R. W. Sharp, L. H. Bennett, and E. C. Saeugling 30

An Aid in the Application of Rotenone in Pond Reclamation
-- H. P. Clemens 31

Rearing Young Shad in Ponds
-- J. C. Pearson 33

Trout on a Trolley in Oregon
-- C. C. Jensen 37

Items

Marking Cutthroat Trout With Trypan Blue 9
From Report on Study of Nylon and Linen Gill Nets 18
Pliers for Tagging Fish With Flat Fingerling Strap Tags 32
Method of Sectioning Carp Spines for Growth Studies 36

Reviews

Heterogeneous Stimulus Summation in the Release of Spawning Activities in Fish - by Eric Fabricius
-- reviewed by K. D. Carlander 38

Natural Selection and Egg Number in Fish - by G. Svärdson

Fertility of Char (Salmo alpinus L.) in the Foxälven Water System, Sweden; Supplement to the Fertility of Char (Salmo alpinus L.) in the Foxälven Water System, Sweden - by A. Määr
-- reviewed by K. D. Carlander 39

Clearing House 40

THE USE OF TORULA YEAST IN THE FEEDING OF TROUT

STUDY OF GROWTH RATE AND VITAMIN VALUES IN WISCONSIN HATCHERIES

Warren S. Churchill
Wisconsin Conservation Department
Woodruff, Wisconsin

FOOD FOR THE REARING of artificially propagated trout is an important item in the budget of the Fish Management Division. The most commonly used foods are the cheaper slaughterhouse byproducts, such as inedible beef liver, pork or beef melts (spleens), and sheep liver, and canned carp prepared by the Rough Fish Control Section. In the past 10 years, the packing-house products have become scarcer and more expensive, and there has been a continuous search for substitute foods to lower the cost of rearing trout.

The present paper is concerned with the use of torula yeast, Torulopsis utilis, as a food supplement in the rearing of trout. Torula yeast is a byproduct of the sulphite pulp industry, and its production is a result of the efforts of this industry to solve the problems of waste disposal. Sulphite waste liquor is commonly discharged into surface water, creating a serious pollutional problem. Organic materials, particularly sugars, in the liquor create a high biochemical oxygen demand with consequent depletion of dissolved oxygen. By the growth of torula yeast, these substances can be removed from the waste liquor and converted into a usable form.

EXPERIMENTAL PROCEDURE

A preliminary experiment in the feeding of yeast was conducted at the Lakewood hatchery in the summer of 1949. Fifty pounds of brook trout fingerlings in each of three circular ponds were fed a mixture of pork melts and canned carp, substitutions of yeast being made as follows:

Pond	Percent meat	Percent yeast
A	100	0
B	90	10
C	80	20

All fish were fed at the same theoretical rate, 8.1 percent of their weight per day. As this was based on the weight of fish at the beginning of each 2-week period, with no adjustment for growth during the period, the actual feeding rate ranged from 6.5 to 7.4 percent of the weight of fish, depending on the rate of growth. The growth of fish in these three ponds is shown in figure 1.

A second experiment was begun on March 20, 1951. Forty-two pounds of brook trout fingerlings averaging 550 per pound were equally divided into six troughs in the Lakewood hatchery. A feeding schedule was set up, based on the Cortland feeding tables,[1/] as shown in table 1.

The Cortland tables list the recommended feeding rates for young trout in terms of percent of weight of fish per day. These amounts vary according to the size of the fish and the temperature of the water. In calculating the feeding schedules, this percentage was taken as the base rate, and diets were calculated as percentages of this rate. Thus, if the Cortland figure for a given temperature was 5.0 (5 percent of weight of fish), fish in tank 2 would be fed 4.5 percent (90 percent of 5 percent) of their weight in liver and 0.5 percent (10 percent of 5 percent) of their weight in yeast. Total feedings for three of the tanks were less than the base rate. Tables were prepared to show the amount of each ingredient to be fed to each tank of fish at any temperature within the anticipated range. These amounts were based on the weight of each lot of fish at the time the tables were prepared. Every 2 weeks the fish were weighed and new tables were prepared.

Food was weighed on a Pelouze dietetic scale which was accurate to 1 gram. Feedings of liver were therefore correct within 1 percent, but the amount of yeast may have varied

1/ Tunison, A. V. Trout feeds and feeding. U. S. Fish and Wildlife Service. Mimeographed, 1945.

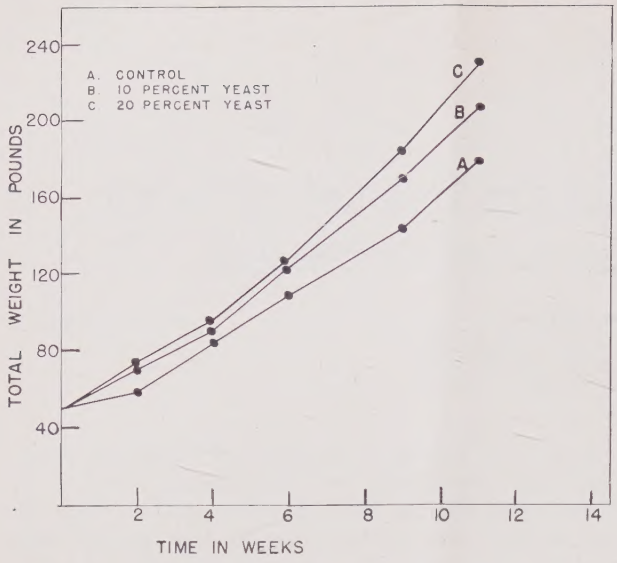


FIGURE 1.--Growth of trout in preliminary experiment.

up to 5 percent. The day's ration was weighed at one time but was fed in two installments.

Fish were weighed in water on a platform scale to the nearest ounce, or within 1 percent. (There is always an error in the weighing of live fish in this way, owing to water carried over with the fish; however, an experienced hatcheryman can hold this error almost constant, so that it is canceled when gain in weight is calculated by difference.)

For two principal reasons, the actual rate of feeding differed from that scheduled:

1. Diurnal temperature fluctuations at Lakewood may be as high as 20° F. Each morning the foreman estimated the average daily temperature on the basis of the morning temperature and his own experience. As all rations were based on the same temperature, any discrepancy here would not affect the comparison of different rations.

2. Feeding was calculated from the weight of each lot of fish at the beginning of each period. By the end of the period, the weight had increased considerably, so that the fish were receiving a measurably smaller percentage of their weight per day. The approximate feeding rate for each lot has been calculated from the total of the food fed during each 2-week period and the average of the weight at the beginning and end of each period.

The original plan was to keep each lot of fish intact, each lot to be divided into two tanks when it needed more room. Lack of space in the hatchery made this impossible, so that it was necessary to reduce each lot of fish on two occasions. At the third weighing (April 28), each lot was reduced to 8 pounds; at the sixth weighing (June 9), each lot was reduced to 10 pounds. Each reduced quantity of fish was weighed out without sorting, in order not to change the size distribution or average size of fish in each lot.

The weights of each lot of fish at each weighing appear in table 2.

TABLE 1.--Feeding schedule for Lakewood yeast experiment: Part 1

Tank number	Percent of Cortland diet			Composition	
	Beef liver	Torula yeast	Total	Percent liver	Percen yeast
1	100	0	100	100	0
2	90	10	100	90	10
3	70	20	90	78	22
4	70	10	80	88	12
5	80	10	90	89	11
6	100	0	100	100	0

TABLE 2.--Weights of fish fed on liver and yeast
(Expressed in pounds)

Tank number:	1	6	1 & 6	2	3	4	5
Percent							
Liver:	100	100	100	90	70	70	80
Yeast:	0	0	0	10	20	10	10
March 20	7.00	7.00	7.00	7.00	7.00	7.00	7.00
April 1	8.63	8.56	8.60	8.44	8.12	8.56	8.50
April 14	10.00	10.06	10.03	10.19	10.31	10.00	10.25
April 28	12.87	13.25	13.06	13.25	12.63	12.81	13.06
All tanks reduced to 8.00 pounds							
May 13	9.81	9.62	9.72	9.94	9.62	9.88	10.19
May 26	15.00	14.75	14.88	15.00	14.12	14.06	14.62
June 9	21.69	22.12	21.90	22.00	19.94	18.75	20.31
All tanks reduced to 10.00 pounds							
June 23	14.31	14.88	14.60	15.31	15.00	14.62	15.31
July 7	17.38	18.31	17.85	19.38	18.81	18.06	19.25

After the final weighing (on July 7), this phase of the experiment was discontinued and the fish were pooled and sorted. Forty-two pounds of even-sized fish were placed in six tanks for the second phase of this

TABLE 3.--Feeding schedule for Lakewood feeding experiment: Part 2

Lot number	Basic diet	Torula yeast	Brewers' yeast
1 & 2	100	0	0
3	90	10	0
4	70	20	0
5	70	10	0
6	80	10	0
7	70	0	10
8	70	0	20

experiment. This second phase was set up in the same manner as the first phase had been, except that a mixture of canned carp and pork melts (approximately half and half) was used as the basic diet instead of beef liver. The proportions of the two ingredients varied slightly from week to week but were the same for all lots in any one week. After the first weighing, two additional lots of fish of the same size were added and fed a mixture of basic diet and brewers' yeast. At this time the six original tanks were reduced to 7 pounds apiece. The diets used during this experiment are shown in table 3.

TABLE 4.--Weights of fish fed on carp, pork melts, and yeast
(Expressed in pounds)

Lot number:	1 & 2	3	4	5	6	7	8
Diet							
Basic:	100	90	70	70	80	70	70
Torula:	0	10	20	10	10	0	0
Brewers':	0	0	0	0	0	10	20
July 7	7.00	7.00	7.00	7.00	7.00	-	-
July 21	9.19	9.50	9.75	9.31	9.56	-	-
	All tanks thinned to 7.00 pounds, July 21						
August 7	8.88	9.75	10.00	9.56	9.50	9.19	9.44
August 21	9.97	11.25	12.19	11.00	11.00	10.44	10.75
September 6	11.25	13.19	14.19	12.62	12.81	12.00	12.69
September 20	12.72	15.12	16.50	14.50	14.62	13.81	-

The weights of each lot of fish at each weighing appear in table 4. Because of an error in the preparation of the feeding table for the last period, Lot 8 did not receive the correct diet. The last weight of this lot has therefore been omitted from the calculations.

Mortality in all lots of fish in both series was negligible. No difference in the appearance or behavior of the various lots was observed at any time. After both series of experiments, representative fish from each lot were killed and examined. No significant difference was noted in appearance, condition of organs, stored fat, or muscle texture.

CALCULATIONS

For use in evaluating the various rations, the following quantities were measured or calculated for each lot for each period: the number of days in period, the weight at beginning of period, the weight at end of period, the gain during period, the percent gain during period, the average weight during period, the total weight of food fed during period, and the average percent of weight fed per day.

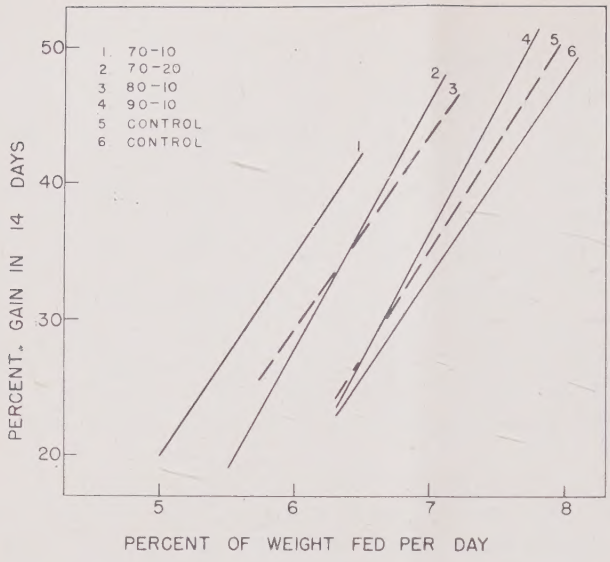
The relationship between rate of feeding and rate of growth has been used as the basis for comparison of the value of the different diets. The rate of feeding and the percent gains for each lot of fish for each period are listed in tables 5 and 6. The figure for percent gain has been corrected to the equivalent of 14 days where the length of the period was different. From each set of figures, the best-fitting straight line was calculated by the least squares method. (See figures 2 and 3.)

It must be remembered that each pair of numbers in a series represents a different set of conditions as regards temperature and age and size of fish. The individual curves therefore give little absolute information about the diets they represent. However, since these variables were identical for all fish at any time, corresponding sets of data for each lot are directly comparable. The calculated curve is a convenient means of comparing all data simultaneously. Under these circumstances, extrapolation is not justified and the curves are shown only for the observed range of feeding rate.

Curves for the liver diet, with and without

TABLE 5.--Rate of feeding and percent gain on diets containing liver and yeast

Lot number:	1		6		2		3		4		5	
Diet												
Liver:	100		100		90		70		70		80	
Yeast:	0		0		10		20		10		10	
Period	Rate	Percent gain	Rate	Percent gain	Rate	Percent gain	Rate	Percent gain	Rate	Percent gain	Rate	Percent gain
1	6.3	27	6.3	26	6.3	24	5.8	19	5.0	26	5.7	25
2	6.6	17	6.6	18	6.6	22	5.6	29	5.3	18	5.8	22
3	6.7	29	6.6	32	6.6	30	6.2	22	5.4	28	6.1	27
4	6.7	23	6.7	20	6.6	24	6.0	20	5.3	24	5.8	27
5	7.0	33	6.9	53	7.0	51	6.6	47	5.8	42	6.5	44
6	7.8	45	7.6	50	7.7	47	7.1	41	6.5	33	7.2	39
7	8.1	43	8.0	49	7.8	53	7.1	50	6.4	46	7.0	53
8	6.6	21	6.6	23	6.5	27	5.5	25	5.3	24	5.8	26



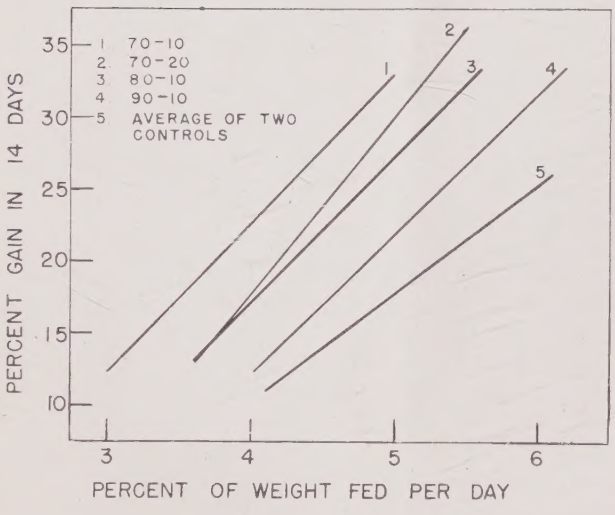


FIGURE 2.--Relation between growth and rate of feeding on diets of liver and yeast.
FIGURE 3.--Relation between growth and rate of feeding on diets of carp, pork melts, and torula yeast.

yeast, are shown in figure 2; those for the carp-pork melt diet with torula yeast are shown in figure 3. As there were fewer observations on the carp-melt diet with brewers' yeast, these are shown separately in figures 4 and 5. For a more accurate comparison, curves for the control diet and the corresponding torula yeast diet were recalculated using only the data corresponding to those obtained for the brewers' yeast diet.

DISCUSSION

All lots of fish given the liver diets grew at approximately the same rate. The controls showed the highest rate of growth in some periods and the lowest in others; in some periods the controls differed from each other more than from other diets. So far as actual growth is concerned, no advantage can be claimed for any of the diets.

However, since the fish were fed different total quantities of food, it is apparent that fish receiving the smallest amounts made the greatest gain per pound of food. This is illustrated by the curves in figure 2, where rate of growth has been plotted against rate of feeding. As total growth was approximately the same, fish fed equal total amounts show similar rates of utilization. The curves therefore fall into three groups, representing those that received 80, 90, and 100 percent, respectively, of the Cortland diet, regardless of composition.

This is taken to mean that even the lowest diets in this phase of the experiment were sufficient to produce near maximum growth. Additional food therefore produced no additional growth and was, in fact, wasted. It appears that this part of the experiment ought to be repeated at a lower level of feeding.

In the second part of the experiment, where a mixture of carp and pork melts was used as the basic diet, differences in growth rate were definite and consistent, as illustrated

TABLE 6.--Rate of feeding and percent gain on diets containing carp-melts and yeast

Lot number:	1 & 2		3		4		5		6		7		8	
Diet														
Carp-melts:	100		90		70		70		80		70		70	
Yeast:	0		10 T		20 T		10 T		10 T		10 B		20 B	
Period	Rate	Percent gain	Rate	Percent gain	Rate	Percent gain	Rate	Percent gain	Rate	Percent gain	Rate	Percent gain	Rate	Percent gain
1	6.3	31	6.2	36	5.5	39	5.0	33	5.6	37	-	-	-	-
2	6.3	22	6.0	32	5.3	35	5.0	30	5.5	29	5.1	26	3.5	29
3	4.7	12	4.7	15	4.5	22	3.7	15	4.2	16	3.8	14	4.6	14
4	4.2	11	4.2	15	3.7	14	3.3	13	3.7	14	3.4	13	3.7	16
5	4.1	14	4.1	16	3.6	18	3.2	16	3.6	15	3.3	16	3.2	-

T - Torula yeast.
B - Brewers' yeast.

in table 4. The control diet here was not sufficient for maximum growth, and all lots of fish that received yeast grew more rapidly than the controls. The greatest growth was achieved by the fish fed 70 percent basic diet and 20 percent torula yeast.

When growth rates are calculated in terms of rate of feeding (figure 3), it appears that fish on the 70-10 torula diet showed the greatest gain per pound of food, while the controls again showed the least. In fact, the curves for the five diets fall in the same relative position on the graph as those for the liver diet (figure 2). They do not, however, fall into the same close grouping--which reflects the difference in growth rate as well as in rate of feeding.

Both torula and brewers' yeast were used in 70-10 and 70-20 diets. All four of these diets resulted in better growth than the controls. In both cases the torula diet produced better growth than the corresponding brewers' yeast diet. The growth curves for these diets and the controls are compared in figures 3 and 4. It appears that torula yeast is more effective than brewers' yeast in the same amounts.

Thus far all calculations and comparisons have been based on the total weight of food, regardless of composition. A comparison on the basis of dry weight shows a different picture. The various meat products used for fish food contain about 70 percent moisture, whereas yeast contains less than 10 percent. A pound of yeast therefore contains about three times as much food material as a pound of liver or other wet food (table 7).

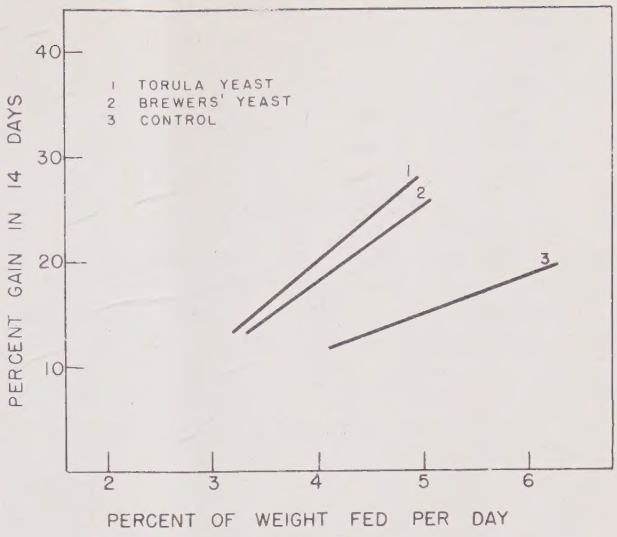
Using the figures 30 percent and 90 percent, respectively, as the dry weight of meat products and yeast, it appears that the dry weight of a pound of each of the various diets is as follows:

Diet	Dry weight (pound)
Control	0.30
90-10	.36
70-20	.43
70-10	.37
80-10	.37

At the rates of feeding used, the dry weights of equivalent feedings of the various diets compare as follows:

Diet	Dry weight
Control	100
90-10	120
70-20	130
70-10	100
80-10	117

Figures 6 and 7 are made from the same data as figures 2 and 3, but the rate of feeding



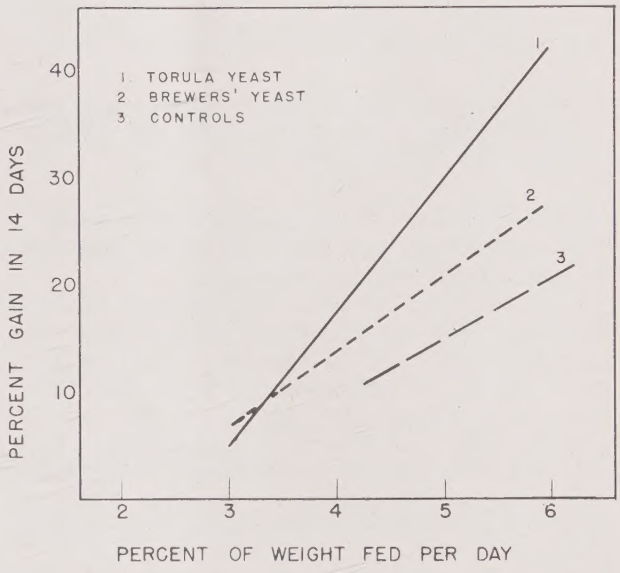


FIGURE 4.--Comparison of torula and brewers' yeast in 70-10 diet.
FIGURE 5.--Comparison of torula and brewers' yeast in 70-20 diet.

TABLE 7.--Analysis of fish foods

	Beef liver[1]	Canned carp[1]	Pork melts[2]	Torula yeast[3]
Moisture	69.70	70.07	-	6.5
Protein	19.70	12.33	17.0	48.0
Fat	3.20	8.44	1.9	1.0
Ash	1.40	2.58	1.4	8.8
Fiber	-	0.21	-	3.8
N. F. E.	-	6.37	-	33.0
Carbohydrate	6.00	6.58	-	-

[1] D. J. O'Donnell. (Unpublished)
[2] A. V. Tunison. Trout feeds and feeding. U. S. and Wildlife Service. Mimeographed, 1945.
[3] Lake States Yeast Corporation.

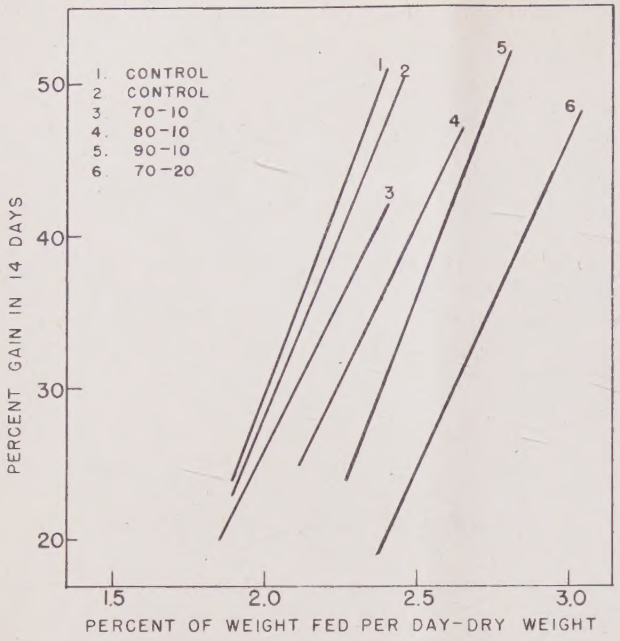


FIGURE 6.--Relation between growth and rate of feeding on diets of liver and yeast, on a dry-weight basis.

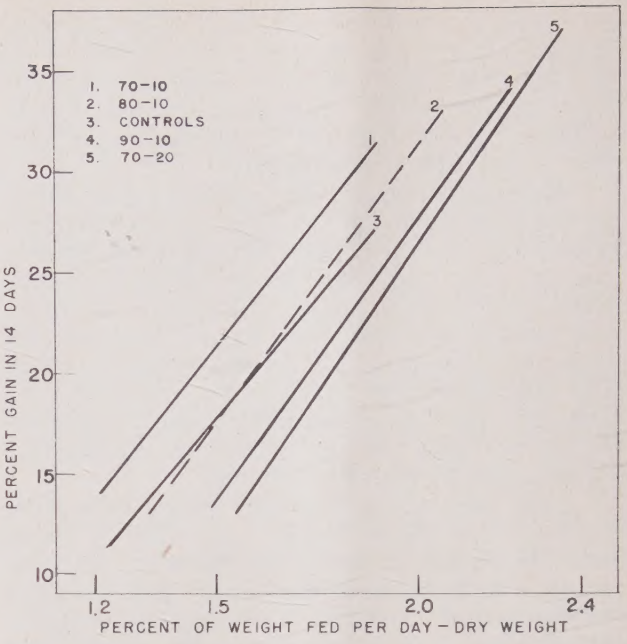


FIGURE 7.--Relation between growth and rate of feeding on diets of carp, pork melts, and torula yeast, on a dry-weight basis.

is recalculated on the basis of dry weight. Here again the best conversion is achieved at the lowest feeding rates.

In the liver series, this formula appears slightly less efficient in producing growth than the control; in the carp-melt series, the formula appears somewhat more efficient. These differences are small and may not be significant, but there is a suggestion that the food material in torula yeast is somewhat less nutritious than that of liver but more nutritious than that of the carp-pork melt mixture.

VITAMINS

Analyses for B-complex vitamins were made on the control diet of carp and pork melts alone and with the addition of 10 percent and 20 percent torula yeast. The results appear in the first three columns of table 8. The fourth column lists the requirements of brook trout, as determined by Phillips (1949) and Phillips and Brockway (1949). In a food fed at the rate of 6 percent of body weight per day, the minimum concentration of each vitamin that would cause maximum storage in the liver was somewhere between the two values in this column. This was taken to be the minimum requirement. The last two columns show the vitamin content of beef liver, as determined by these authors, and of torula yeast.

The carp-melt diet here is far below these requirements for all vitamins. This diet or a similar mixture of herring and pork melts has been extensively used in some Wisconsin hatcheries. Larger fingerling and yearling brook trout have been fed such a diet for long periods without showing any recognizable symptoms of vitamin deficiency. In view of present information, it seems highly probable that such fish have actually suffered to some extent from vitamin deficiency and would have

TABLE 8.--Vitamin content of hatchery foods
(Micrograms per gram)

Vitamin	Lakewood control	Control + 10 percent yeast	Control + 20 percent yeast	Requirements of brook trout	Beef liver	Torula yeast
Thiamine	0.230	1.900	3.720	2.500 - 3.100	4.200	5.13 - 14.43
Riboflavine	2.200	6.300	9.800	7.400 - 11.400	40.500	33.16 - 70.20
Niacin	32.800	73.800	111.100	50.000 - 69.000	95.000	153.00 - 478.00
Pantothenic acid	11.100	18.400	21.000	16.200 - 20.800	55.300	39.00 - 123.00
Biotin	.065	.226	.435	.113 - .448	1.283	.50 - 8.30

enjoyed better health and growth if fed a vitamin supplement. On the other hand, it is entirely possible that the minimum requirements of trout are actually lower than the tentative figures based on storage in liver. Phillips and Brockway pointed out this possibility, as they also found no symptoms of deficiency at lower levels of feeding. In any case, a diet that contains the amounts that they recommend can be used with confidence.

The addition of 20 percent torula yeast to the carp-melts diet brings the content of all five vitamins well into or above the prescribed range. Ten percent torula yeast leaves the diet somewhat below this standard in thiamine and riboflavine. The 70-10 diet, containing 12 percent yeast, would probably give an adequate amount of all five vitamins. In diets containing a reasonable proportion of beef liver, the additional vitamins in the yeast are of little significance.

At the time of writing, the cost of beef liver used for feeding trout was $13.80 per 100 pounds and that of torula yeast was $8 per 100. The carp-pork melts mixture cost $7.86. It is obvious that at these prices considerable savings can be effected by the use of torula yeast and accompanying reduction of total quantity of food.

Hatcherymen who have used torula yeast report favorably on its physical qualities. It mixes easily with wet foods and acts as a binder to improve the consistency of the mixture. The only labor involved in its use is the actual mixing, and this is offset by the fact that there is less wet material to be handled and ground.

ACKNOWLEDGMENTS

Acknowledgments and thanks are extended to the Lake States Yeast Corporation for furnishing the yeast used in these experiments and for making vitamin assays, and to Dr. Averill Wiley of the Sulphite Pulp Manufacturers' Research League, Inc., for his assistance and suggestions throughout the project. The feeding and care of fish were handled by Messrs. Henry Wurzer, Raymond Schottky, and Harry Laughlin of the Wisconsin Conservation Department.

LITERATURE CITED

Phillips, A. M., Jr.
1949. The vitamin B requirement of trout. Trans. Am. Fish. Soc. 76 (1946): 34-45.

------ and Brockway, D. R.
1949. The niacin and biotin requirement of trout. Trans. Am. Fish. Soc. 77 (1947): 152-159.

MARKING CUTTHROAT TROUT WITH TRYPAN BLUE

TRYPAN BLUE, readily injected into the fins and other parts of 150 cutthroat trout (Salmo clarkii clarkii) from the Alsea Trout Hatchery of the Oregon State Game Commission, gave prominent marks at the time of injection but failed to remain in the tissues. Trials of this stain in April-June 1951 have been reported by Carl E. Bond of Oregon State College and Ray Culver of the Oregon State Game Commission, Corvallis, Oregon.

Cutthroat trout 6 to 10 inches in length were anesthetized with urethane and then were marked with a 1-percent solution of trypan blue in 0.85 percent sodium chloride injected by means of a 2-milliliter insulin syringe and No. 26 hypodermic needle. The volume of the stain used was not measured, but each fish received an amount sufficient to give the mark desired.

Injections on the mentum made the point of the jaw quite blue, whereas injections along the mandible produced mostly fine blue lines and some suffusion of stain into surrounding tissues. By inserting the needle at a point about one-quarter inch anterior to the base of a pectoral fin and then pushing the needle into the region of the bases of the fin rays before injecting the stain, it was possible to stain the fin a deep and uniform blue which could easily be observed as the fish swam in the pond. Both pelvic fins took the color well when the needle was inserted on the midline of the belly and just anterior to the bases of the fin rays.

Fish examined 3 weeks after injections appeared to be in good health, but only faint traces of blue remained on a few fish. In the single instance of mortality during the 2-month period, a fish that died 3 days after being marked on the mandible, the stain had neither faded nor spread.

An Interim Report on Gill Disease

Robert R. Rucker, Harlan E. Johnson, and George M. Kaydas
U. S. Fish and Wildlife Service
Seattle, Washington

GILL DISEASE among fish, a disease which is characterized by a proliferation of the gill epithelium, has been attributed to a number of different causes. Generally, there are two recognized types: the eastern or bacterial type, in which long filamentous bacteria can always be demonstrated; and the western type, in which, by definition, bacteria cannot be demonstrated.

LITERATURE SURVEY

Osburn (1911) at the New York Aquarium found that 89 out of 486 silver salmon yearlings had shortened gill covers--the posterior portion was turned under. He found that the gill epithelial cells, instead of being a single flattened layer, were cuboidal and columnar and two or three layers thick. The thickening of the gill was attributed to the remedial process, protecting the delicate gill filaments from the friction created by a lack of the gill cover.

Plehn (1924) described further the proliferation of the gill epithelium, mentioning that the filaments may even grow together into a solid mass. She also mentioned that fish so afflicted actually suffocate because of the impaired gas exchange through the gill epithelium. She thought that the proliferation was due to a chemical in the water and that the structures suspected of being microscopic parasites were probably pathological epidermis cells.

Davis (1926) described a similar-appearing gill disease which he attributed to irritation by a filamentous bacterium on the surface of the gills. A therapeutic treatment with copper sulfate destroyed the bacteria, and in most cases the fish quickly recovered from the infection and the gills resumed their normal appearance. It was, therefore, surmised that the etiological agent was bacterial.

Fish (1935) described the progressive pathology of the gills of a fish affected with what he called a western type of bacterial gill disease. Although he implies that this disease is caused by an organism because two types of bacteria (neither characteristic of the eastern gill disease bacterium) were demonstrated on smears made from infected gills, he writes: "Which one, if either, of these organisms is responsible for the western type of gill disease is not known." No method of treatment employed, including salting, controlled the disease. This is of interest because Wolf (1935) found that copper sulfate was of no value in the treatment of gill disease but that 10-minute baths in a 3-percent salt solution were extremely effective.

Wales and Evins (1937), studying a gill disease problem at a trout hatchery, reported:

> In conclusion we can say that two factors are active in this particular gill disease. In the first place, certain hatchery waters are polluted by diatoms, other small algal forms, bacteria and protozoa. This foreign matter is very injurious mechanically to the gills of certain strains of trout. In the second place, certain strains of trout are more easily injured than others by the above-mentioned foreign matter.

The name "Sestonosis" was selected for this gill disease because it was believed to be caused by a mixture of living and nonliving bodies which float in water.

Fish (1941) found that an infection by the flagellated protozoan ectoparasite, Costia necatrix, can cause an irritation to the gill epithelium wherein tissue alteration comparable to the earlier stages of gill disease may be produced.

Wolf, reporting on a study of gill disease (1944), said:

> ... the cause of the condition can now positively be stated to lie in dietary failure--specifically lack of one of the B vitamins, pantothenic acid. Bacteria

and certain environmental factors, once thought to be the cause of the disease, are now known to play only a secondary role.

This work was confirmed by Tunison and his associates (1944), who found that the addition of pantothenic acid to the diet corrected the disease condition among fish showing gill disease from a lack of this vitamin.

Wolf, summarizing his work of the last 10 years, reported (1945) that he was unable to transmit gill disease to healthy fish by holding diseased fish with them, by feeding diseased gills, or by introducing mass cultures of the mixed bacterial flora from the diseased gills grown on agar plates. He inferred that chemical irritation from excretory products of the fish caused the hyperplasia of the respiratory epithelium and thus produced the characteristic lesion of gill disease; he found that fish can develop a certain resistance to this irritation. From the results of various chemical treatments on infected fish, he failed to find any support for a theory of bacterial etiology of gill disease. Salt treatments were beneficial; the benefit was shown to be caused by the salt absorbed into the body fluids. He produced a gill disease causing death in 23 days among brown trout fingerlings on a diet of pork spleen (30 parts), meat meal (63), gelatin (7), and water (60). This diet, because of its pantothenic acid deficiency, increased the susceptibility of the respiratory epithelium to chemical irritation.

Ordal and Rucker (1944), studying bacterial gill disease, consistently isolated myxobacteria from the gills of infected fish. The systematic position of these cultures that failed to produce organized fruiting bodies was not determined. Continuing these studies, Dr. Ordal has found (private communication) different types of myxobacteria associated with gill disease. There were outbreaks of gill disease in which myxobacteria could be cultured from the organs as well as from the gills. These outbreaks did not respond to external therapy. Outbreaks of gill disease in which myxobacteria were isolated from the gills but not from the organs were less severe and responded to external therapy. Because of the response to therapy and because the organism can be recovered consistently from the gills and organs of moribund fish, Dr. Ordal believes that myxobacteria are the etiological agent in some types of gill disease.

Burrows (1949, and private communication) has demonstrated at least two causes of gill

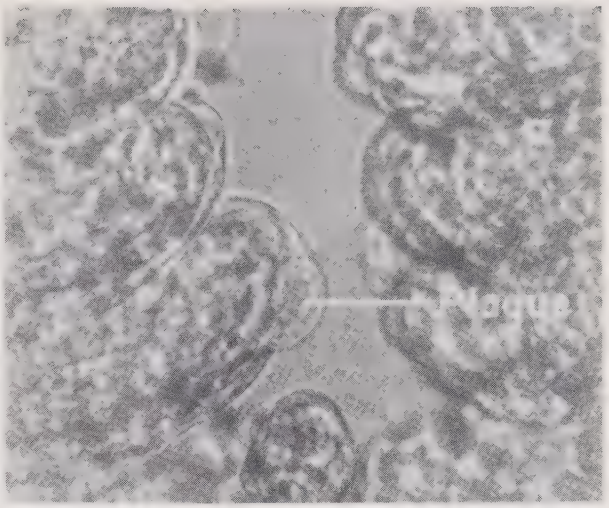


FIGURE 1.--Gill of a blueback salmon fingerling showing a plaque on a lamella. x500.

disease. While making observations on the development of the bacterial type of gill disease, he found that a bacterium that forms colonies resembling plaques on the gill filaments may be the primary invader. The size of these plaques varied somewhat. The plaque shown in figure 1 was about 30 microns long and 10 microns deep. The plaques were oval and flat and had bacteria projecting outward. When the plaques first appeared, there was some proliferation of the gill epithelium and the fish were listless. Next, the typical gill bacteria were seen on the gills in conjunction with the plaques. Soon the plaques were no longer visible; only the typical filamentous bacteria were present. More extensive clubbing of the gills and fusion of the filaments followed. Treatment of these diseased fish with a disinfectant resulted, first, in the removal of the bacteria, which disclosed the plaques; then the plaques lost their granular appearance, and the diseased gills seemed to return to normal condition. At the Federal fish-cultural station at Leavenworth, Washington, 1-hour treatments of pyridylmercuric acetate (1:500,000) are administered weekly as a prophylactic. If this is not done, the eastern or bacterial type of gill disease develops and causes severe losses.

Burrows also observed a type of gill disease among spring chinook salmon fingerlings in the hatchery. In the spring of the year, when the fish had reached a certain size, they made a definite effort to migrate downstream, congregating at the tail screen. If the fish were held, the western type of gill disease developed. If the pantothenic acid content of the diet of the fish was increased,

the urge to migrate and the development of disease were delayed for about a month and the mortality rate was reduced.

EXPERIMENTAL DATA[1/]

According to the literature, the cause of gill disease certainly can be attributed to many factors. In order to cope more effectively with this disease, a better understanding of it was needed; therefore, a number of experiments were conducted. Some of these are briefly summarized here.

Shortened Gill Covers

The effect of shortened gill covers on blueback salmon (Oncorhynchus nerka) was tested by cutting off the posterior portion of one operculum. This was done to 200 fingerlings that weighed about 1.8 grams each on August 22, 1947. The gills of recently dead fish were examined periodically to detect the presence of a proliferation of the gill epithelium, but a gill disease condition had not been found when the experiment was terminated on December 3, 1947.

Irritants

The effect of an ammonium compound on the gills of fish was tested by having a concentrated solution of ammonium chloride drip into the head end of a fish trough at a rate that would give a concentration of 1:1,000,000. The experiment was started on August 28, 1947, and terminated on December 11, 1947. This experiment involved 200 blueback salmon fingerlings averaging 1.9 grams each. During this time no evidence of gill disease could be found.

In another trough, a quantity of dirt was maintained and was roiled periodically. None of the fish which were held in this trough for a number of weeks developed a gill disease.

Bacteria

All attempts to transmit gill disease to fish by the introduction of bacteria into the water supply failed. Myxobacteria in pure culture were isolated from the gills of infected fish at the Leavenworth (Washington) Station: these bacteria could never be recovered from internal organs of infected fish. The myxobacteria were grown in broth and on agar plates; both types of culture were used to maintain the organism in the water. No fish developed gill disease.

Nutrition

Our first attempt to produce gill disease in a group of silver salmon (O. kisutch) fingerlings was made with Cortland's Diet No. 823 (Tunison et al. 1944), the pantothenic acid deficient diet containing 50 percent pork melts and 50 percent dry feed. No evidence of disease was found among these fish even after 4 months on this diet.

Next, Wolf's diet (1945) of pork spleen (30 parts), meat meal (63), gelatin (7), and water (60), was fed to a group of 200 blueback salmon fingerlings (averaging 1.7 grams) from August 20, 1947, to December 3, 1947. The mortality was rather high in this group (which developed an anemia), but no evidence of gill disease was ever found.

Wolf's recent diet work on trout (1951) may prove to be the first successful synthetic diet for use in studies on fish nutrition and pathology. Not until we tried this diet, were we able to produce gill disease under controlled conditions. In our desire to observe the effects of a pantothenic acid deficient diet on salmon, we conducted the following experiment.

Four lots of approximately 2,125 chinook salmon (O. tschawytscha) fry, each lot weighing 1,000 grams, were transferred to tanks just as the yolk-sac scar had begun to heal. Each of the tanks, 60 inches by 24 inches with a 21-inch water level, was supplied with 3 gallons a minute of filtered, dechlorinated domestic water. The fish were first fed for a month on fresh beef liver to eliminate those mortalities due to an inability to feed and to allow the fish to reach a more substantial size before the experimental diets were begun.

The diets were prepared according to the specifications of Wolf (1951) and McLaren (McLaren et al. 1947). Each diet was made up fresh every 2 weeks and was kept under refrigeration at all times. When feeding of the experimental diets was initiated, the fish were fed as much as they would eat; but as feeding activity increased and the fish accepted the diets more readily, the diets were fed at the level of 6 percent of the body weight of the fish per day.

McLaren's diet proved deficient for chinook salmon fingerlings. One lot of fish was begun on the complete diet and another on the pantothenic acid deficient diet on March 12, 1951. Beginning about the sixth week of the experimental feeding, mortalities increased rather

---

[1/]Facilities for this work were furnished by the School of Fisheries, University of Washington, Seattle, Washington.

FIGURE 2.--Chinook salmon fingerlings raised for 9 weeks on synthetic diets. Left to right: McLaren and associates' (1947) diet, same deficient in pantothenic acid, Wolf's (1951) pantothenic acid deficient diet, and Wolf's complete synthetic diet.

sharply and gill disease was diagnosed in both lots. No external lesions were found on these fish: only the proliferation of the gill epithelium was evident. The red-blood-cell count on April 24 indicated 1,250,000 cells per cubic millimeter in these two groups of fish. The average size of these fish on May 12 is shown in figure 2; the mortalities are indicated in table 1. By May 12, there were so few fish left that this section of the experiment was terminated.

TABLE 1.--Weekly mortalities, expressed as percent, for blueback salmon fingerlings held on experimental diets initiated on March 12

Date	Diets of McLaren et al. (1947)		Diets of Wolf (1951)	
	A	B	B	A
March 10	0.5	0.7	0.5	0.4
March 17	.2	.8	1.0	.4
March 24	.3	.7	.4	.5
March 31	.2	.3	.5	.3
April 7	.4	.4	.4	.3
April 14	.1	.5	.2	.1
April 21	6.2	4.9	1.7	.3
April 28	52.2	50.4	13.4	.2
May 5	45.1	45.3	12.3	2.0
May 12	22.8	12.8	5.0	1.9
May 19	-	-	35.5	1.8

A - Complete diet.
B - Pantothenic acid deficient diet.

Wolf's diet (1951) proved sufficient for the rearing of chinook salmon fingerlings. One lot of fingerlings was started on the complete diet, and another lot on the pantothenic acid deficient diet, on March 12, 1951. The lot fed Wolf's complete diet for the full 10-week period of the experiment[2/] exhibited mortalities that seem to be within the normal expectancy. During the last 3 weeks of the experiment, a number of fish jumped out of the tanks and were lost. These fish are included in the mortality figures, accounting for the slight rise in percent mortality. No evidence of disease was found among these fish; the gill color was excellent.

The lot that was fed Wolf's pantothenic acid deficient diet showed a sharp rise in the mortality rate in the latter part of the

2/Concomitant to our work on the deficient diet, Halver and Coates (unpublished) conducted feeding tests on chinook salmon fingerlings with a modification of Wolf's diet, using vitamin-free casein instead of the commercial casein that we used. At the termination of our experimental work, all of our fish being fed Wolf's complete diet were transferred to their care. They continued to feed these fish and their fish on the test diet until July 12, 1951. At this time the fish (when they were being planted) handled and appeared in excellent condition. Halver and Coates maintained chinook salmon fingerlings on the test diet for 20 weeks.

sixth week after experimental feeding was started: gill disease was then found. The degree of fusion of the gill filaments varied greatly, ranging from 5 to 80 percent. Gill color in almost all cases compared favorably with the red color of the fish fed Wolf's complete diet for the full 10 weeks. Some of the moribund fish exhibited no fusion of the gill filaments but were thin and emaciated. None of these fish bore any external lesions. Samples were taken from all groups of fish for a histopathological study at a later time.

The fish given Wolf's pantothenic acid deficient diet were divided into two equal groups on April 28, when gill disease was quite extensive. One group was continued on the deficient diet; the other was fed the complete diet, starting April 30. The daily mortalities of these two groups and of the group maintained on the complete diet from the start of the experiment are shown in table 2. It seems apparent that the fish on the deficient diet were only lacking in pantothenic acid, as the fish returned to normalcy when this vitamin was supplied.

TABLE 2.--Daily mortalities for groups of blueback salmon fingerlings raised since March 12 on Wolf's (1951) complete experimental diet and pantothenic acid deficient diet. On April 28 half of the deficient fish were placed on the complete diet.

Date	Complete diet (2,109 fish)	Deficient diet continued (885 fish)	Deficient diet changed to complete diet (885 fish)
Apr. 30	1	50	107
May 1	2	18	32
May 2	1	9	18
May 3	4	15	18
May 4	1	6	10
May 5	0	11	9
May 6	-	-	-
May 7	3	18	7
May 8	7	5	2
May 9	0	2	5
May 10	2	2	1
May 11	2	4	6
May 12	3	8	0
May 13	-	-	-
May 14	7	20	3
May 15	5	33	4
May 16	3	53	3
May 17	0	62	2
May 18	1	52	0

LITERATURE CITED

Burrows, R. E.
1949. Lecture notes of Leavenworth in-training school. U.S.D.I., Fish and Wildl. Serv.

Davis, H. S.
1926. A new gill disease of trout. Trans. Am. Fish. Soc. 56: 156-160.

Fish, F. F.
1935. A western type of bacterial gill disease. Trans. Am. Fish. Soc. 65: 85-87.
1941. Notes on Costia necatrix. Trans. Am. Fish. Soc. 70 (1940): 441-445.

McLaren, B. A.; Keller, E.; O'Donnell, D. J.; and Elvehjem, C. A.
1947. The nutrition of rainbow trout. I. Studies of vitamin requirements. Arch. Biochem. 15 (2): 169-178.

Ordal, E. J., and Rucker, R. R.
1944. Pathogenic myxobacteria. Proc. Soc. Exp. Biol. and Med. 56 (1): 15-18.

Osburn, R. C.
1911. The effect of exposure on the gill filaments of fishes. Trans. Am. Fish. Soc. 40: 371-376.

Plehn, M.
1924. Praktikum der Fischkrankheiten. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 179 pp.

Tunison, A. V.; Phillips, A. M., Jr.; Shaffer, H. B.; Maxwell, J. M.; Brockway, D. R.; and McCay, C. M.
1944. The nutrition of trout. Cortland Hatchery Report No. 13 for 1944. N. Y. Cons. Dept. Fish. Res. Bull. 6, 21 pp.

Wales, J. H., and Evins, D.
1937. Sestonosis, a gill irritation in trout. Calif. Fish and Game 23 (2): 144-146.

Wolf, L. E.
1935. Some experiments in treatment of gill disease. Fish Cult. 1 (4): 5-13. N. Y. Cons. Dept. Bur. Fish Cult.
1944. Thirty-third annual report for the year 1943. N. Y. Cons. Dept., pp. 111-112.
1945. Dietary gill disease of trout. N. Y. Cons. Dept. Fish. Res. Bull. 7, 30 pp.
1951. Diet experiments with trout. Prog. Fish-Cult. 13 (1): 17-24.

COMPARISON OF THE GROWTH OF LAKE TROUT FINGERLINGS FROM EGGS TAKEN IN SENECA, SARANAC, AND RAQUETTE LAKES

David C. Haskell
New York Conservation Department
Rome, New York

THE PROPAGATION of the lake trout (Cristivomer namaycush) is an important part of the hatchery production of New York State. Eggs are obtained from wild fish by netting operations in several of the lakes of the State. Ordinarily, eggs are obtained from Seneca Lake, Raquette Lake, and Saranac Lake, although occasionally eggs have been taken from Keuka Lake, Lake George, Paradox Lake, and others. Because of geographical location, the Seneca eggs are propagated at the Bath and Caledonia hatcheries, and the fish reared are used to stock the lakes in the Finger Lake region of the State. Saranac eggs are usually hatched at the Saranac and Chateaugay hatcheries, and the fish are stocked in the Adirondack section of the State. Fish from the Raquette eggs are reared at the Lake George hatchery, and the fish are stocked in the eastern and southeastern lakes. Some of the fish produced from the eggs of each lake are stocked into the lake from which they came: seldom has there been any exchange of fish in restocking, such as the planting of Seneca fish in Raquette Lake. The fact that by September the Seneca fingerlings at the Bath hatchery are always much larger than the Raquette fingerlings at the Lake George hatchery led to the belief that the Senecas, over a period of years, had developed more rapid growth characteristics. Royce (unpublished data) presents evidence based on studies of spawning habits to indicate that the lake trout in Seneca Lake represent a race different from that found in many of the Adirondack lakes. This experiment was designed to compare the relative growth rates of Seneca, Raquette, and Saranac lake trout fingerlings under uniform hatchery conditions.

EXPERIMENTAL METHODS

The egg yield of each strain was held at one hatchery: the Senecas at the Bath hatchery, the Saranacs at the Saranac hatchery, and the Raquettes at the Warrensburg hatchery. As soon as the eggs were "eyed and shocked," each hatchery chose the eggs from one day's "take," mixed them thoroughly, and removed three lots of about 10,000 each. The three lots were then transferred so that each of three hatcheries--Bath, Caledonia, and Lake George--had one lot of each of the three strains.[1/] The eggs and fry were cared for in the regular manner, and the experiment was started 10 days after feeding began.

At the start of feeding, many of the known factors affecting growth were made uniform. The controlled factors were as follows:

Troughs.--Standard rearing troughs.

Water flow.--10 gallons per minute for first 10 days; 15 gallons per minute thereafter.

Sanitation.--Troughs cleaned daily; salt bath administered weekly.

Diet.--Trimmed beef liver.

Grinding of feed.--Made uniform for all lots at any particular size, but changed as average weight of fish increased.

Method of feeding.--Dipper with perforated bottom.

Amount of feed.--Based on table prepared by Tunison,[2/] but slight increase above table allowed because of excessive waste in feeding small lots.

Weighing.--Samples weighed weekly to adjust amount of feed.

Density.--Weight of fish per cubic foot of water controlled on basis of predetermined table based on definite weight for each size of trout.

[1/] The Seneca and Raquette eggs for the Lake George hatchery were held at the Warrensburg hatchery until hatched.

[2/] Tunison, A. V. Trout feeds and feeding. U. S. Fish and Wildlife Service. Mimeographed, 1945.

RESULTS

Several comparisons of importance are possible from the data.

1. Comparison of size at end of experiment. Sizes of the fish in the nine lots at the end of the experiment on September 1 are listed in table 1. These results show that on September 1 the Senecas were by far the largest, the Saranacs were second in size, and the Raquettes were the smallest. The differences are large enough so that it is obvious that the Senecas are the only logical choice to produce the largest fish for stocking in September. On the other hand, this comparison neglects the difference in age of the strains on this date, and the differences in water temperature at which they were reared.

2. Comparison of these sizes at equal ages. Table 2 offers a comparison of the sizes of the fish in the various lots at equal ages, at the end of 6 months. This comparison again shows that the Senecas were largest, the Saranacs in second place, and the Raquettes were smallest. The average growth curves for the three strains are plotted in figure 1. It will be noted that the curves for the Senecas and the Saranacs are practically coincident until the last month of the experiment.

3. Comparison of the sizes at equal ages and in equal water temperatures. Comparisons of the growth of trout are not convincing to the fish-culturist unless the water temperatures for the lots are the same. In this experiment, equal water temperatures were impossible because the temperatures at the three hatcheries were different and varied at each hatchery with the season. The Senecas started feeding on January 3, the Raquettes on January 31, and the Saranacs on February 16. Thus, the Senecas were feeding for more than 2 months before the water temperature started to rise with the coming of spring; on the other hand, the Saranacs had been feeding only a short time before the temperature rose (figure 1). The average water temperature, as a result, was lowest for the Senecas and highest for the Saranacs.

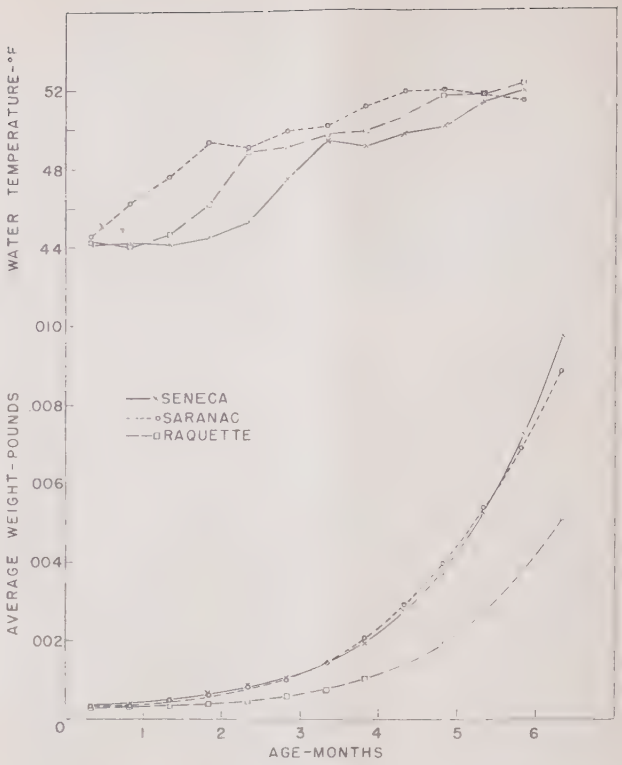


FIGURE 1.--Average growth of three strains of lake trout.

TABLE 1.--Average weight of fish (and number of fish per pound) on September 1, 1942

Strain	Date of initial feeding	Average weight[1/] (and number per pound) at hatchery						Strain mean	
		Bath		Caledonia		Lake George			
Seneca	Jan. 3, 1942	0.0256	(39)	0.0213	(47)	0.0131	(76)	0.0200	(50)
Saranac	Feb. 16, 1942	.0119	(84)	.0089	(126)	.0065	(153)	.0091	(110)
Raquette	Jan. 31, 1942	.0088	(113)	.0093	(107)	.0060	(166)	.0080	(125)

[1/] In pounds.

TABLE 2.--Average weight of fish (and number of fish per pound) after 6 months

Strain	Average weight[1/] (and number per pound) at hatchery						Strain mean	
	Bath		Caledonia		Lake George			
Seneca	0.0120	(83)	0.0104	(96)	0.0067	(148)	0.0097	(103)
Saranac	.0119	(84)	.0089	(126)	.0065	(153)	.0091	(110)
Raquette	.0061	(163)	.0052	(192)	.0040	(250)	.0051	(196)

[1/] In pounds.

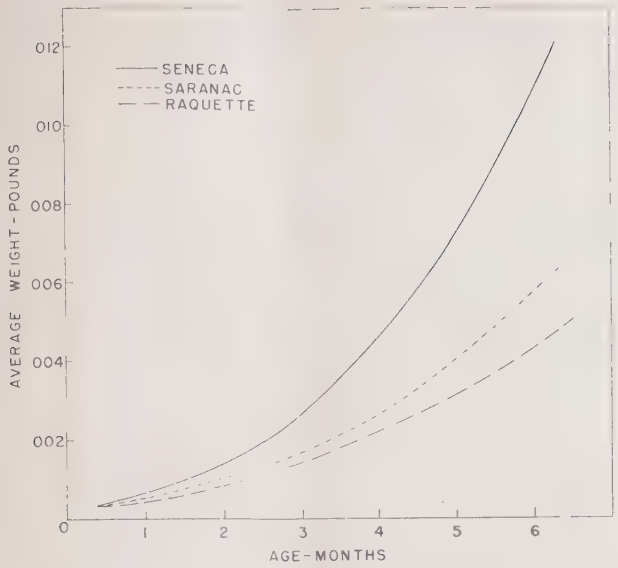


FIGURE 2.--Calculated growth of the three strains of lake trout at an "average" hatchery at 48.6° F.

Statistical methods were used to make an approximate adjustment for temperature differences and to determine the growth rate and final size which could have been expected had the water temperature been constant. The basis for this adjustment is the change in growth rate evidenced by the three strains as the water temperature varied during the experiment.

Before this step was taken, it was necessary to select a measure of growth. This measure should be (1) unaffected by the age of the fish and (2) linearly related to water temperature. The cube root of the average weight was selected, and the increase in the cube root for each period was used to measure growth as explained by Haskell (1948).

The details of the statistical work are not included here. The following steps were taken:

1. Compute and tabulate the cube root of the average weight per fish at the end of each period. $\sqrt[3]{\bar{W}}$.

2. By subtraction, calculate for each lot $\sqrt[3]{\bar{W}_1} - \sqrt[3]{\bar{W}_0}$, $\sqrt[3]{\bar{W}_2} - \sqrt[3]{\bar{W}_1}$, etc., where W_0 is the average weight at the start, W_1 is the average weight at the end of the period 1, etc.

3. Tabulate the increments of $\sqrt[3]{\bar{W}}$ vs. water temperature in the form for covariance analysis (Snedecor 1940).

4. Compute the "within lot" regression coefficient of the increment of $\sqrt[3]{\bar{W}}$ on temperature.

TABLE 3.--Expected increase of the cube root of average weight[1/] per semimonthly period at 48.6° F.

Strain	Expected increase at hatchery			Strain mean
	Bath	Caledonia	Lake George	
Seneca	0.306	0.334	0.234	0.291
Saranac	.242	.231	.156	.210
Raquette	.190	.210	.141	.180

Analysis of variance

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	8	0.31794	-
Strains	2	.19851	0.09925
Hatcheries	2	.11528	.05764
Error	4	.00415	.001037

F (strains) = 95.5** F (hatcheries) = 55.5**

[1/]Average weight is in ten-thousandths pounds.

5. Adjust the original values of the increment of $\sqrt[3]{\bar{W}}$ to the mean temperature of the experiment.

6. Add successive adjusted increments to $\sqrt[3]{\bar{W}_0}$ for each lot to obtain adjusted values of $\sqrt[3]{\bar{W}}$.

7. Tabulate $\sqrt[3]{\bar{W}}$ vs. period for each lot in form for covariance analysis.

8. Calculate the regression coefficients of the adjusted values of $\sqrt[3]{\bar{W}}$ on period for each lot. These regression coefficients are the best available estimates of the expected increase in $\sqrt[3]{\bar{W}}$ in one period and may be used for comparison of the growth of the several lots at constant temperature.

The analysis in table 3 indicates that in the period of the experiment the Senecas had a definitely superior growth rate, while there was little difference shown between the Saranacs and the Raquettes after the adjustment had been made for differences in water temperatures. Using the results in table 3, growth curves were calculated to give a visual representation (figure 2) of the results. To complete the consideration of the data, the calculated attained sizes at the end of 6 months, at a constant water temperature of 48.6° F., have been listed in ten-thousandths pounds (with the number of fish per pound in parentheses) as follows:

Senecas ---- 120.5 (83)
Saranacs --- 62.6 (160)
Raquettes -- 47.1 (213)

CONCLUSIONS

1. In hatchery practice, the relative growth rates of the fingerling lake trout

of the three strains reared in New York State are obscured by two circumstances. First, because of a difference in spawning times, the fingerlings from eggs of wild fish from Seneca Lake usually start to feed nearly a month earlier than those taken from Raquette Lake, and 6 weeks earlier than those from Saranac Lake; thus, at any given time, comparison favors the older strains. Second, the strains which regularly start to feed earliest in the winter have the longest period of cold weather before spring and consequently the lowest average temperature. This tends to reduce the growth rate of the strains which start to feed earliest. A fair comparison of the growth rates requires a study at equal ages and an adjustment of growth rate to compensate for different water temperatures.

2. When adjustment of the growth rates for temperature differences has been made and the strains are compared at equal ages, the Seneca fingerlings have a more rapid growth rate than the fingerlings from Raquette and Saranac Lakes. Growth rates of Raquette and Saranac fingerlings are nearly the same.

3. The data suggest that careful selection of a source of eggs from wild fish is fully as important as selective breeding of those species for which the brood stock is reared in the hatchery.

ACKNOWLEDGMENTS

The experimental data were collected by Donald Cope, Howard Russ, and L. D. Winslow, foremen of the Lake George, Caledonia, and Bath hatcheries, respectively.

LITERATURE CITED

Haskell, D. C.
1948. Graphical method for presenting data on the growth of trout. Prog. Fish-Cult. 10 (2): 59-61.

Snedecor, G. W.
1940. Statistical methods. Iowa State Coll. Press, Ames, 422 pp.

FROM REPORT ON STUDY OF NYLON AND LINEN GILL NETS

A STUDY conducted on seven inland lakes from June 17 to September 9, 1950, to determine the relative efficiencies of nylon and linen gill nets, has recently been reported by Kenneth L. Peterson of the Institute for Fisheries Research, Michigan Department of Conservation.

A lake survey crew laid 56 companion sets of nets, pairing a nylon net with a linen gill net and placing the pairs in various depths of water. Each pair was fished for a comparable length of time.

Each net was 125 feet long by 6 feet deep and had five sections of different-sized mesh (stretch measure: 1½, 2, 2½, 3, and 4 inches). Thread sizes for the nylon nets were (from the smallest to the largest mesh) Nos. 46, 46, 69, 104, and 104; for the linen, 50/2, 45/3, 40/3, 35/3, and 30/3. The nylon thread (Brownell preshrunk) was colorless; the linen (treated with copper naphthenate) was drab.

In 38 sets the nylon net took more fish than its linen companion; in 16 sets the linen net outcaught the nylon; and in 2 sets the catches were equal. In 30 sets, however, the difference between the catches of the two nets was 5 or less; in 18 other sets the difference did not exceed 15.

Perch and rock bass were the most numerous of the species taken. The linen nets took more perch than the nylons, but the nylon nets took the greater number of rock bass.

Largemouth bass and pumpkinseed sunfish were the next most numerous of the species taken. The average catch of largemouth bass in the linen nets exceeded that in the nylon nets, but the average catch of pumpkinseed sunfish was greater in the linen nets than in the nylon nets.

Data regarding the catch--1,841 fish, 995 in nylon nets and 846 in linen--have been analyzed statistically to decrease bias arising from the placements of the pairs. For all species, the nylon nets had an average catch of 17.77 ± 1.63, and the linen nets had an average catch of 15.11 ± 1.51. Here the value of t is 1.74, and the probability that the difference (2.66 ± 1.53) is significant is 91 percent.

Lengths and weights of the game fishes were recorded. Comparison of average sizes showed that yellow perch in the nylon nets were 0.4 inch longer, but that pumpkinseed sunfish and yellow pike-perch in the linen nets were 0.3 inch longer. Rock bass averaged the same in both types of net.

THE EFFECTS OF SUPPLEMENTAL FATS IN THE DIET OF BROOK TROUT

Arthur M. Phillips, Jr.
U. S. Fish and Wildlife Service

Donald R. Brockway
New York Conservation Department

and

John M. Maxwell
U. S. Fish and Wildlife Service
Cortland, New York

FATS IN THE ANIMAL BODY serve as a source of immediate energy, as a reserve source of energy, as insulation against climatic changes, as a protection for the vital organs, and as a lubricant for many of the moving parts. Fats also serve as carriers for the so-called fat-soluble vitamins (D, E, K, and A). Fat in the body is derived from the food that is eaten: fat may be deposited from the fats in the diet or may be formed from excessive carbohydrates and proteins. That fats are essential in the diet has been demonstrated with the higher animals. It has been found that at least one of the fatty acids (the building blocks of fats) is needed to maintain a normal healthy animal.

Two types of fat are found in the animal body: the constant and the variable. The constant fat is that which is present in the body cells even after long periods of starvation and apparently represents the minimum amount of fat necessary to maintain life. The variable fat, as the name indicates, fluctuates widely from animal to animal and may vary considerably in the same animal over periods of time. The variable fat is dependent upon the food eaten, and overeating of any or all of the food groups (protein, fat, or carbohydrate) may result in an excessively fat animal. It is well known that animals that are greatly overweight are not desirable over a long range, but little work has been done to determine the effect of fat on the physiology of the trout. The Cortland workers recently have started such experiments in the hope that some information may be gained as to the utilization of these substances and their effects upon the fish.

Several authors have reported that cod-liver oil in the diet of trout resulted in an increased rate of growth of the fish (Davis 1927; Gutsell 1939, 1948; Phillips et al. 1948, 1949, 1950). These papers did not indicate whether the increased rate of growth was due to the vitamin content (A and D) of the oil, a combination of the vitamins, the energy of the oil itself, or to some other unknown factor.

McLaren and associates (1947) concluded that the addition of corn oil to the diet of rainbow trout produced beneficial effects, not from the angle of growth, but as measured by the fat content of the body and the reduced mortality of the fish.

McCay and Tunison (1935) fed cottonseed oil (a commercial oil suitable for human consumption) for 32 weeks and reported that it was evident that the oil was utilized. This diet, together with one containing crisco (hydrogenated cottonseed oil), showed an increased rate of growth in comparison to the control diets. Later these authors (1936) conducted balance trials, using salmon and cottonseed oil as well as crisco. They found that the oils were equally digested (about 90 percent) even though one was of fish and the other of vegetable origin, whereas only about 70 percent of the crisco (a harder fat than the two oils, solid at room temperature) was digested.

PROCEDURE

During the summer of 1950, experiments were run at the Cortland Hatchery to study the effect of several oils upon the growth rate, mortality, and chemical composition of the body. Two vegetable fats (corn and cottonseed oil) and two fish fats (cod-liver and salmon oil) were added to the standard diet of this hatchery at two levels (3 and 5 percent of the diet). The fish were held in troughs supplied with water at a temperature of 47° F. and the experiments were run

for 22 weeks. The fish were handled according to the established procedure of this laboratory (Tunison et al. 1939).

At the end of 16 weeks, groups of fish were removed from each of the experimental troughs, killed, dried under vacuum, and then ground in a mortar. Analyses were then made for the fat, ash, and protein content of the various dried and ground trout. Also, the character of the fat was established by determining the iodine number of the fat extracts.[1/]

The original intention was to take samples of fish for analysis at the end of the experimental period (22 weeks), but only one series was made.

All differences were tested statistically by means of analysis of variance. The diet composition is listed in table 1, and the results are summarized in table 2.

EXPERIMENTAL RESULTS

The addition of corn oil did not increase the rate of growth at either level in comparison to the control diets and did not alter the mortality rate of the fish. The total percent of fat in the body was increased beyond that of the control, although the higher level of oil did not produce a greater storage of fat than the lower.

Whether the increase in body fat was beneficial or not, certainly appears debatable. In terms of actual trout production, the deposition of fat could hardly be classified as true growth, as it was not fish flesh or protein that was deposited. The growth rate of trout fed corn oil was similar to that of trout receiving the control diet, but the bodies of the oil-fed trout showed considerably higher fat content. It would appear logical to conclude that even though the two groups showed similar average weights at the end of the experimental period, the fish fed corn oil, showing the higher fat content and hence a smaller amount of trout flesh per animal, actually gained less than the control lot.

The effect of corn oil on the body fat of the fish was reflected by the increased iodine number of the body fat. As, in general, the iodine number of a fat is a measure of hardness (melting point), the higher iodine number of the fat indicates a softer body fat, providing additional proof of the utilization of the dietary oil.

TABLE 1.--Percentage composition of the diets

Diet No.	Beef spleen	Dry mix 6a[1/]	Corn oil	Cotton-seed oil	Cod-liver oil	Salmon oil
1193	50	50	-	-	-	-
1194	50	50	-	-	-	-
1195	47	50	3	-	-	-
1196	47	50	3	-	-	-
1197	45	50	5	-	-	-
1198	45	50	5	-	-	-
1199	47	50	-	3	-	-
1200	47	50	-	3	-	-
1201	45	50	-	5	-	-
1202	45	50	-	5	-	-
1203	47	50	-	-	3	-
1204	47	50	-	-	3	-
1205	45	50	-	-	5	-
1206	45	50	-	-	5	-
1207	47	50	-	-	-	3
1208	47	50	-	-	-	3
1209	45	50	-	-	-	5
1210	45	50	-	-	-	5

[1/]Composed of 24 parts each of wheat middlings and cottonseed meal, 48 parts fish meal, and 4 parts salt.

The addition of cottonseed oil at either level resulted in almost no growth over the 22-week period. The iodine number of the body fat indicated that the fish were utilizing the oil, but the total fat content of trout fed this oil was lower than the fat content of the fish fed the regular diet. The low growth rate was further evidenced by the reduced protein content of the body. The feeding of this oil caused an increased mortality, and the surviving trout were in extremely poor physical condition.

This study is in agreement with the work of McCay and Tunison (1935) in that the iodine number of the body fat clearly indicates the absorption of the oil into the body. The earlier study, however, did not show a similar lack of growth and increased mortality, possibly because the grade of oil used was better.

There appears to be a wide variation in the amount of gossypol in various cottonseed oils (Eagle et al. 1948; Iwai and Nakamura 1944; Williams et al. 1949), and this may best explain the difference between the present experiments and those of McCay and Tunison (1935).

As in earlier work, the addition of cod-liver oil at a 3-percent level resulted in growth rates that far exceeded those of the control diets. Increasing the amount of the dietary oil to 5 percent reduced the growth rate below that of the control fish. These

[1/]Methods for analyses: fat, ether extract; ash, to constant weight in a furnace; iodine number, Hanus; protein, micro-nitrogen, Hengar.

experiments, therefore, established the limit of cod-liver oil at about 3 percent of the diet for optimum growth. Both levels of the oil increased the total body fat, and an increase in the iodine number was found. There was no percentage increase in the protein content of the body; but, because there was an increase in fish size, the number of grams of protein per individual was greater in the fish fed cod-liver oil (3-percent level).

In this case it is felt that there was a gain in fish flesh, in spite of the increased fat deposition. This is due to the stepped-up growth, and it is believed that the addition of the fat definitely was beneficial. These results are in decided contrast with those from corn oil, which produced increased fat at the same growth rate as the controls.

Salmon oil produced results similar to those noted for cod-liver oil. At the 3-percent level there was a marked increase in the rate of growth, the total body fat was greater in comparison with the controls, and the iodine number of the body fat was increased. The 5-percent level did not show the marked decrease in growth rate that appeared when the same level of cod-liver oil was fed. During the last three 2-week periods of the experiment, however, the fish fed the greater amount of salmon oil were showing a decreased rate of growth as compared with that of the fish given the lesser amount of oil. It is believed that if the experiment could have been continued for a longer period, a definite and significant reduction in growth rate would have been observed.

In several instances the trout fed both the cod-liver and the salmon oil showed a significant increase in mortality over short periods. This may possibly be traced to the stepped-up rate of growth resulting from the oil. Phillips and his associates (1949) pointed out that trout fed diets containing cod-liver oil showed a higher loss when these diets were not additionally fortified with either beef liver or dried brewers' yeast, possibly because of an increased requirement for the vitamin biotin.

DISCUSSION

In regard to growth rate, neither corn oil nor cottonseed oil had any beneficial effect when added to the diet of trout; in fact, cottonseed oil was detrimental. The feeding of either cod-liver oil or salmon oil at a 3-percent level was beneficial; the 5-percent levels were either detrimental or less effective than the lower amounts.

The cod-liver oil and salmon oil are good sources of vitamins A and D. It is probable that some combination of the vitamins or some other unknown substances are responsible for the increased rate of growth resulting from

TABLE 2.--Effect of dietary fat upon the chemical composition of brook trout

Diet number	Added fat	Percent fat	Iodine number	Percent protein[1/]	Percent ash	Average weight end[2/]	Percent average 2-week mortality	Total percent gain	Percent water
1193	none	3.75	92.2	14.1	2.0	10.78	2.2	1,180	78.5
1194	none	3.10	92.6	13.7	1.7	9.45	2.2	1,025	80.3
1195	(3/)	5.55	106.9	14.8	2.2	10.00	2.7	1,090	75.6
1196	(3/)	5.30	103.3	14.3	1.9	9.40	2.2	1,019	78.0
1197	(3/)	5.05	107.9	13.7	2.0	9.46	2.5	1,026	78.6
1198	(3/)	4.90	108.3	13.9	2.0	9.20	3.2	999	78.5
1199	(4/)	2.65	111.0	13.5	2.3	1.73	4.9	106	80.6
1200	(4/)	2.75	108.3	12.5	2.4	1.54	4.7	85	82.0
1201	(4/)	1.55	121.2	11.3	2.1	.90	7.6	7	84.5
1202	(4/)	2.00	117.9	10.4	2.0	1.30	9.9	55	84.6
1203	(5/)	4.80	105.6	15.2	1.8	17.30	4.3	1,620	77.6
1204	(5/)	4.70	103.5	13.6	1.9	14.24	3.1	1,595	79.0
1205	(5/)	5.60	109.6	15.0	1.9	8.75	3.1	944	77.0
1206	(5/)	4.70	107.4	11.3	1.6	7.39	2.1	781	81.4
1207	(6/)	5.45	101.6	14.6	2.0	13.70	2.4	1,530	76.1
1208	(6/)	5.90	109.5	14.3	1.9	18.80	3.3	2,139	76.9
1209	(6/)	5.35	103.7	14.3	1.8	12.70	3.8	1,412	77.8
1210	(6/)	5.90	109.5	12.7	1.5	14.75	4.1	1,660	78.1

[1/] Analyses made by E. M. Wood.
[2/] Weight at start, 0.84 gram.
[3/] Corn oil.
[4/] Cottonseed oil.
[5/] Cod-liver oil.
[6/] Salmon oil.

the addition of these oils, and that the energy factor alone is not responsible. Corn oil may prove to be a useful tool in future studies of this nature because of its low vitamin content, utilization (as indicated by increased body fat and high iodine number of the fat deposited), and failure to alter the growth rate of the trout.

Gains alone should not be used in evaluating the effects of diets on growth. Corn-oil diets and the control diets produced the same gains; but it is felt, because of the higher fat content, that the trout which were fed corn oil actually gained less weight in terms of flesh produced. Even though trout fed the fish oil showed an increase in body fat, as compared with the controls, the greater gain in weight certainly demonstrated a correspondingly greater production of fish flesh. The oils in these instances were no doubt beneficial.

LITERATURE CITED

Davis, H. S.
1927. Some feeding experiments with trout fingerlings. Trans. Am. Fish. Soc. 57: 281.

Eagle, Edward; Castillon, L. E.; Hall, C. M.; and Boatner, C. H.
1948. Acute oral toxicity of gossypol and cottonseed pigment glands for rats, mice, rabbits and guinea pigs. Arch. Biochem. 18 (2): 271-277.

Gutsell, J. S.
1939. Fingerling trout feeding experiments, Leetown, 1938. Prog. Fish-Cult. 45: 32.
1948. Cod-liver oil in the diet of trout. Prog. Fish-Cult. 10 (2): 81-83.

Iwai, Masayoshi, and Nakamura, Kimitoshi
1944. Gossypol in cottonseed oil. II. Coloration of crude cottonseed oil. Jour. Soc. Chem. Ind. Japan 47: 325-328.

McCay, C. M., and Tunison, A. V.
1935. Report of the experimental work at the Cortland Hatchery for the year 1934. N. Y. Cons. Dept., 17 pp.
1936. Cortland Hatchery Report No. 4 for the year 1935. N. Y. Cons. Dept., 17 pp.

McLaren, B. A.; Keller, E.; O'Donnell, D. J.; and Elvehjem, C. A.
1947. The nutrition of rainbow trout. II. Further studies with purified rations. Arch. Biochem. 15: 179-

Phillips, A. M., Jr.; Brockway, D. R.; and Rodgers, E. O.
1948. The nutrition of trout. Cortland Hatchery Report No. 17 for the year 1948. N. Y. Cons. Dept. Fish. Res. Bull. 12, 30 pp.

------ Brockway, D. R.; Bryant, Maurice; Rodgers, E. O.; and Maxwell, J. M.
1949. The nutrition of trout. Cortland Hatchery Report No. 18 for the year 1949. N. Y. Cons. Dept. Fish. Res. Bull. 13, 30 pp.

------ Brockway, D. R.; Kolb, A. J. J.; and Maxwell, J. M.
1950. The nutrition of trout. Cortland Hatchery Report No. 19 for the year 1950. N. Y. Cons. Dept. Fish. Res. Bull. 14, 24 pp.

Tunison, A. V.; Phillips, A. M., Jr.; Rodgers, E. O.; Mitchell, C. R.; and McCay, C. M.
1939. The nutrition of trout. Cortland Hatchery Report No. 8. N. Y. Cons. Dept., 33 pp.

Williams, P. A.; Hadden, R. P.; Hall, C. M.; Castillon, L. E.; Guice, W. A.; O'Conner, R. T.; and Boatner, C. H.
1949. Processing cottonseed oil. IV. Effect of preparation and cooking of meats on the bleach color and storage properties of screw-processed oils. Jour. Am. Oil Chem. Soc. 26: 28-34.

Artificial propagation has shown marked success in saving from extinction two rare subspecies of trout, Salmo beardslei and S. crescentis. These trout, occurring in Lake Crescent, within the Olympic National Park, have been so heavily fished that their survival has seemed doubtful.

In the past 2 years, since the provision of the necessary facilities at the U. S. Fish-Cultural Station at Quilcene, Washington, the Fish and Wildlife Service has taken spawn at Lake Crescent, transported the eggs to Quilcene, and there produced numbers of these trout for return to the lake.

A METHOD OF CALCULATING FISH PRODUCTION IN REARING PONDS

John Dobie
Minnesota Department of Conservation
St. Paul 1, Minnesota

THE CHRONIC SUMMER SHORTAGE of bait minnows in Minnesota has led the Department of Conservation into a program of direct aid to minnow propagators and a 4-year research program on minnow rearing problems.

Eggs of the common or white sucker (Catostomus commersonii) are stripped and eyed in Bureau of Fisheries hatcheries, where some 65,600,000 eggs were handled in 1950. The eyed eggs or newly hatched fry are rationed without charge among minnow-dealer applicants at a rate of 40,000 per acre of rearing pond operated by the dealers. Each dealer must call for and transport the fish to his rearing sites, usually natural rearing ponds.

The Research Unit of the Bureau operated 13 such ponds in 1948, 15 in 1949, and 8 in 1950, to learn more about the physical and chemical standards necessary for bait production, characteristics of food production, minnow growth rates, and general pond behavior (Dobie 1948; Dobie and Johnson 1951). During the development of the research program, new techniques and standards have been devised to fit the special conditions found in large, natural, bait rearing ponds in relatively northern latitudes.

Two techniques are described at this time: (1) a method of estimating a minnow-pond population, from the early fall harvest back to any point in the summer growing season, in order that a computed fish abundance for any date can be correlated with the known natural food supply data for the same date, and (2) a method of expressing pond production in pounds of fish reared within units of pond volume and growing time.

ESTIMATION OF REARING-POND FISH POPULATIONS

In the study of rearing-pond behavior, it often is necessary to know how many pounds of fish are supported by a known poundage of food organisms. The food poundage can be determined at any time in the growing season through use of two net samples (Dobie 1951), but the fish poundage often cannot be computed until the pond is harvested at the end of the summer. A method for estimating the fish populations in numbers and pounds for any date during the rearing period is especially desirable on cropped ponds where the total yield at the end of the harvest is usually much greater than the poundage present or supported in the pond at any one time.

The difficulties in determining populations in ponds by test seining methods are well known (Krumholz 1951). The method now used in Minnesota to estimate fish populations is based on the known harvested quantity of bait fish, thus eliminating one unknown sampling error in pond production figures.

One assumption and three requirements must be stated in explanation of the method. It is assumed that the fish reared in the bait ponds (usually suckers in Minnesota) are not cannibalistic, and that fry surviving the first 2 weeks of insect predation or adjustment to new foods will survive until harvest time with negligible mortality.

It is first required that fish populations suffering mortalities from summerkill, or having recruitment from continuous spawnings (as in golden shiner ponds), be excluded from the following computation procedure.

It is next required that during the growing season a series of fish lengths and weights be obtained at 2-week intervals from each pond and be plotted on length and weight graphs (figures 1 and 2). Growth-rate studies made on 1,065 adult suckers from 102 Minnesota lakes in 21 counties (studies made during routine lake surveys of the past 5 years) indicated that the growth of small suckers displays a straight-line length-age relationship. Wisconsin studies agree (Spoor 1938). The sucker growth picture for the very young

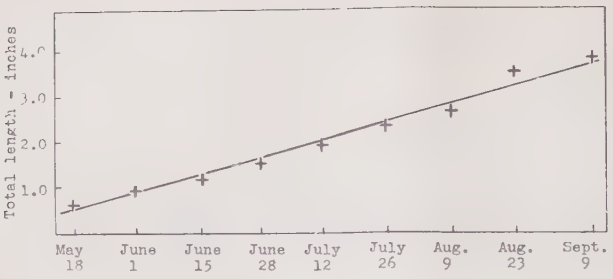


FIGURE 1.--Lengths of suckers (Catostomus commersonii) at certain dates after planting in Becker Pond, Minnesota, 1949.

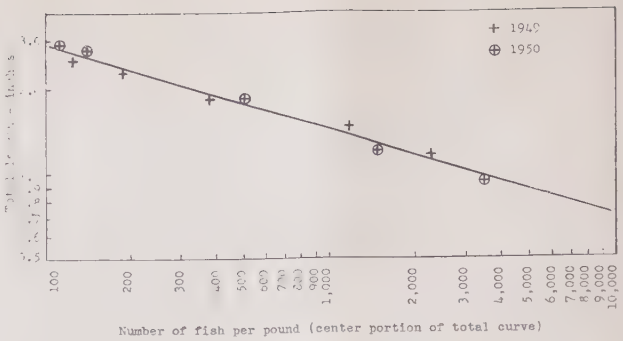


FIGURE 2.--Length-weight relationship in young suckers, Becker Pond, Minnesota, 1949 and 1950.

is therefore drawn as a straight line even though the midsummer lengths on figure 1 are a bit low. "Curves" for shallow ponds more easily seined show a better straight-line distribution of the points.

Last requirement is that a complete record of the fish harvest be kept to show dates and number of fish seined on each date. Weights harvested would also be useful but are not absolutely necessary.

Data from Becker Pond, Hubbard County, in northwestern Minnesota, meet these requirements and will be used to illustrate the method. Comparison will then be made with two ponds of different character and location. General chemical and physical characteristics of the three ponds are shown in table 1.

Becker Pond was stocked with approximately 260,850 free-swimming sucker fry on May 14, 1949. The pond was free from oxygen depletion during the rearing season. Detailed collections of the growing fish were made every 2 weeks (table 2), as well as studies of the plankton foods, bottom soils and organisms, and chemical and physical conditions. Harvest or cropping began August 8, 1949, (table 3) and continued until September 15, 1949, when the total number of suckers harvested reached 112,884.

To yield this number of fish, Becker Pond must have held at least 112,884 suckers on the day harvest began, although the actual number present probably was somewhat higher. There also could have been no fewer in the pond back through the weeks to June 1, the date of the first bi-weekly collection of data (table 4, column 2).

With the "known" population expressed as the number of fish per acre and acre-foot (table 4, columns 3 and 4), and with average lengths and number of fish per pound obtained from the bi-weekly collections (table 4, columns 5 and 6), the minimum poundage of fish present on any date is determined by dividing the number of fish per acre-foot by the number of fish per pound. For example: Becker Pond fish averaged 0.85 inch in total length and 5,400 to the pound on June 1, 1949. With no fewer than 7,118 fish per acre-foot present then, the poundage would be 1.3 per acre-foot. On August 7, the number of fish was at the same theoretically minimum level, but the fish had grown to 2.7 inches and 120 per pound. The weight per acre-foot therefore had increased to 59.2 pounds through normal growth of the young suckers.

A word of explanation is needed for the minor differences in total lengths of suckers at comparable dates in tables 2 and 4. Table 2 shows the actual total lengths obtained by measuring samples of suckers collected at bi-weekly intervals. From these lengths a growth "curve" was constructed--actually a straight line in early growth history. Lengths of

TABLE 1.--Chemical and physical characteristics of three sucker rearing ponds studied in Minnesota, 1949

Pond name and location	Area in acres	Maximum depth in feet	Volume in acre-feet	Chemical analysis in p.p.m. averaged from bi-weekly samples[1/]		
				Phosphate	Nitrogen	Alkalinity
Becker, Hubbard County	[2/]5.24	10	15.86	0.052	1.20	69.6
Nelson, Dakota County	2.85	4	2.97	.270	1.77	32.4
Pond Three, Hennepin County	2.55	6	5.75	.074	2.24	110.6

[1/] Ten analyses from Becker, 16 from Nelson, and 16 from Pond Three.
[2/] Computed from aerial photos, according to methods outlined by Dobie and Johnson (1951). Others mapped by plane table.

TABLE 2.--Lengths and weights of suckers collected at regular intervals from Becker Pond, Hubbard County, Minnesota, 1949

Date	Number in sample	Average total length, inches	Actual number per pound
May 18	14	0.57	-
June 1	8	.85	-
June 15	15	1.13	2,222
June 28	13	1.46	1,150
July 12	14	1.84	378
July 26	14	2.29	185
Aug. 9	12	2.63	118
Aug. 23	10	3.58	54
Sept. 9	8	3.68	43

TABLE 3.--Harvest of suckers from Becker Pond, Hubbard County, Minnesota, 1949

Date	Number of fish removed	Fish removed per surface acre	Pounds removed per surface acre
Aug. 8	4,800	916	7.6
Aug. 9	18,000	3,435	29.9
Aug. 17	10,200	1,946	23.7
Aug. 23	16,320	3,114	44.5
Aug. 29	9,960	1,901	34.6
Sept. 5	36,720	7,008	149.1
Sept. 11	4,800	916	22.9
Sept. 13	10,800	2,061	51.5
Sept. 15	1,284	245	6.1
Total	112,884	21,543	369.9

suckers in table 4 were read off this "curve" to offset variation in lengths obtained at the 2-week measuring interval.

Although this method is accurate because it works back from a known population at harvest date, it has the great weakness of not allowing for natural mortality of fishes in each pond. Fortunately, at the time when the numbers of fish may be high, in early weeks of the rearing season, their weights are slight, introducing no great error in pond standing-crop calculations.

UNIT STANDARDS FOR EXPRESSION OF FISH PRODUCTION

The usual method of expressing fish production from lakes or ponds is in terms of pounds yielded per surface acre of water, presumably on the assumptions that bottom organisms are a major part of the food chain and that each acre of the entire bottom produces an equal food supply. It was recently shown in one stratified Michigan lake, however, that nearly all fish foods were produced in the littoral zone and that a production figure based on littoral area alone was more representative of actual conditions (Ball 1948).

One difficulty yet remains, as illustrated by production data from three Minnesota ponds (tables 1 and 5). Becker Pond in northern Minnesota is an infertile pond in a cool latitude. Nelson Pond in south-central Minnesota is fertile but is only 4 feet deep, and summerkills occur. Pond Three in the Twin Cities area requires and receives heavy fertilization each year because of its sterile water source. The theoretical production rating of these ponds is obvious, but the production in pounds per surface acre during 1949 was 369.9 pounds for Becker, only 128.8 for Nelson, and 388.1 pounds for Pond Three. On this standard, there is no clear relationship between pond fertility and fish production: infertile Becker Pond produced nearly as much as did heavily fertilized Pond Three.

TABLE 4.--Reconstruction of Becker Pond sucker population on several dates, 1949

Date	Number of fish in pond	Number of fish per acre	Number of fish per acre-foot	Average total length, inches	Number per pound	Weight per acre-foot
May 14[1/]	260,850	49,780	16,447	0.50	-	-
June 1	112,884	21,543	7,118	.85	5,400	1.3
June 14	112,884	21,543	7,118	1.20	1,750	4.1
June 28	112,884	21,543	7,118	1.60	660	10.8
July 12	112,884	21,543	7,118	2.00	320	22.2
July 26	112,884	21,543	7,118	2.40	175	40.6
August 7	112,884	21,543	7,118	2.70	120	59.2
August 8	108,084	20,627	6,815	2.70	120	56.7
August 9	90,084	17,191	5,680	2.80	115	49.3
August 17	79,884	15,245	5,037	3.00	82	61.4
August 23	63,564	12,138	4,008	3.20	70	57.2
August 29	53,604	10,230	3,380	3.40	55	61.4
September 5	16,884	3,222	1,064	3.60	47	22.6
September 11	12,084	2,306	762	3.80	40	19.0
September 13	1,284	245	81	3.80	40	2.0
September 27	0	0	0	-	-	0.0

[1/] Date and number stocked.

TABLE 5.--Comparative bait minnow production for three Minnesota rearing ponds, 1949

Pond	Production pounds per acre	Production pounds per acre-foot	Number of harvest days	Days of growth	Production pounds per acre-foot per 10 days
Becker	369.9	128.9	8	1/87	2/6.8
Nelson	128.8	123.6	1	148	8.4
Pond Three	388.1	170.8	1	174	9.0

1/Days of growth from stocking date to peak population on August 7, the day before the first harvest.
2/Calculation from peak population of 59.2 pounds per acre-foot rather than the total production of 128.9 pounds per acre-foot.

When production is recalculated to pounds per acre-foot to bring pond volumes into account, some improvement results (table 5). By this method, Pond Three is still high but Becker Pond seems too close to Nelson. Part of this variation is due to the fact that the ponds were cropped in different ways, and the fish grew for different periods of time in each pond. For example: though 128.9 pounds of fish were produced per acre-foot in Becker Pond, the peak population the day before the harvest began probably was only 59.2 pounds (table 4). This poundage represents only a midseason production, probably not what would have been achieved in a full season even without cropping. Therefore, some method of computing production is needed which will take into account the length of growing season.

The production of each of the ponds was then reduced to fish growth in pounds per acre-foot per 10-day period (table 5). Pond Three is high with 9.0 pounds, Nelson close with 8.4, and Becker reasonably low with 6.8 pounds. While there are no absolute values to go by, this series of pond yield figures, based on volume and length of growing season, seems to present a more realistic comparison of the production from all three ponds, more in keeping with what is known of other traits of those ponds.

LITERATURE CITED

Ball, R. C.
1948. Relationship between available fish food, feeding habits of fish, and total fish production in a Michigan lake. Mich. State Coll. Tech. Bull. 206, 56 pp.

Dobie, John
1948. Minnow propagation. Minn. Dept. Cons. Bull. 13, 24 pp.
1951. A method of measuring the natural food content of rearing ponds. Prog. Fish-Cult. 13 (3): 131-134.
------ and Johnson, R. E.
1951. Pond mapping by aerial photographs. Jour. Wildl. Mgt. 15 (2): 221.

Krumholz, L. A.
1951. Further remarks on the minnow seine method of sampling fish ponds. Jour. Wildl. Mgt. 15 (1): 110-112.

Spoor, W. A.
1938. Age and growth of the sucker, Catostomus commersonnii (Lacepede), in Muskellunge Lake, Vilas County, Wisconsin. Trans. Wis. Acad. Sci. Arts and Lett. 31: 457-505.

Some pond owners, recognizing the fact that their ponds will produce only a limited number of pounds of fish, prefer to keep the number of fish under control by stocking only fishes that do not reproduce excessively in the ponds. By this method of control, the owners stock either hybrid fish, which have a very low reproductive potential, or native fish that ordinarily do not live in ponds. Hybrid sunfish (bluegill x redear sunfish), for example, have such an unbalanced sex ratio that introductions have provided the desired results in certain regions. Depending upon the geographical location of the pond, native species such as rock bass and channel catfish have been stocked to maintain the desired numbers. Thus throughout much of the Middle West the rock bass will reproduce but will not overpopulate the pond and the channel catfish will reproduce only as suitable spawning facilities are provided.

Suggestions for the Renovation of Fish Ponds

Ancil D. Holloway
U. S. Fish and Wildlife Service
Atlanta, Georgia

THE RENOVATION OF PONDS requires the making of structural changes that may be necessary to obtain suitable habitat, as well as fish-population changes that may affect the balance between predators and nonpredators. The importance of renovation work was demonstrated in a recent survey which indicated that approximately two-thirds of the ponds in the southeastern part of the United States were not in satisfactory condition (Holloway 1951). This suggests a tremendous job for future years, as there are approximately 225,000 farm fish ponds in the southeastern States.

Bass (Micropterus salmoides) and bluegill (Lepomis macrochirus) have been a satisfactory combination in ponds, the bass being used as a predator and the bluegill as a nonpredator. Other species have been used with this basic stocking to satisfy the particular desires of individual pond owners. Brown bullhead (Ameiurus nebulosus marmoratus), crappie (Pomoxis), redear sunfish (L. microlophus), and yellowbelly sunfish (L. auritus) have been the species most commonly used.

Before suggestions for renovation can be made, it is necessary to determine the state of balance of the fish population. The state of balance ordinarily can be determined by seining. A minnow seine (10 to 12 feet long) and a larger seine (1-inch square mesh, 50 feet long) have been satisfactory for this work.

We have found it useful in this renovation work to classify fish populations in four groups, or as being "bass heavy," "in ideal balance," "static," or "out of balance."

The bass-heavy group includes fish populations characterized by slow growth of bass, or bass in poor condition. Bass are numerous, and practically all the young of the nonpredators are consumed by predation. The bluegills make rapid growth and reproduce abundantly, but there are insufficient adults to provide food from reproduction for satisfactory growth of the bass and adequate escapement for replacements in the nonpredator population. Nearly all the nonpredators are large adults. Considerable variation appears in this type of pond.

If the bass in such a pond are not in poor condition and some recently hatched bluegills are found, heavy fishing for bass will usually correct the situation. In some pools, however, where bass were in poor condition and there was an abundance of small bass with practically no escapement of the small bluegills, the addition of 80 to 120 adult bluegills per acre was necessary to correct the situation within a year. Where adults were not available, the introduction of fingerling bluegills (2 to 3 inches in length) at the rate of 500 per acre corrected the situation. If the fingerling bluegills are introduced in the spring, they will be large enough for many to escape predation and reproduce the same summer.

If a pond is "in ideal balance," there is adequate survival of the bass and bluegills for replacement. All sizes of the bluegill are present; intermediate-size bluegills are not abundant; only recently hatched bluegills are abundant during the spawning season. Rapid growth, heavy reproduction, and excellent fishing are obtained from both species.

The owners rarely request information concerning the management of these ponds. We have noted, however, that unfertilized ponds often become overcrowded with bluegills and other nonpredators as the ponds become older. The overcrowding is usually caused by weed growths that increase in area and density with the increase in age of the pond. Ordinarily, ponds having more than 10 percent of their bottoms covered with weeds will become overcrowded with bluegills in the third summer or in later years. The use of adequate fertilizer to control weeds and the resloping of pond bottoms in the shallow areas to assist in weed control will help to maintain the ideal balance.

Ponds in which renovation work is most needed are those containing fish populations classified as "static." These populations show relatively slow growth of both bass and bluegills, there is only light reproduction of both species, and the fishing is mediocre to poor.

If static ponds can be fertilized to maintain adequate plankton for weed control, such ponds ordinarily will come into ideal balance presently and provide excellent fishing.

Other corrective measures that have been successful include partial poisoning after the young bass of the year have reached approximately 2½ to 3 inches in length. The partial poisoning is done in the areas less than about 3 feet in depth. Ordinarily 1 pound of derris or cube (5 percent rotenone) per 300 feet of shore line, applied on the 3-foot contour (effective 20 to 30 feet from shore) on bright days between 10:00 a.m. and 2:00 p.m., will destroy large quantities of intermediate- and small-sized bluegills--and very few bass. If the control work is done early in the morning, on cloudy days, or late in the afternoon, bass will be feeding in the shallow waters and the results will then be less effective. One-third to three-fourths of the shore line is treated, depending on the severity of the crowding and the width of the area less than 3 feet in depth. Unless partial poisoning is done near the end of the growing season, it usually should be repeated one or more times during the summer.

In ponds where a high percentage of the bluegill population is tied up in an intermediate size, better results have been obtained by poisoning one-fourth to one-third of the pond with rotenone at the rate of 0.5 p.p.m. (Leonard 1939). In ponds where the crowding of bluegills is rather advanced, it may be necessary to do corrective stocking with bass the following spring and, if bass are available, soon after the poisoning is accomplished. Sometimes bass reproduction is satisfactory and sometimes very little occurs in the spring subsequent to partial poisoning. An inspection is necessary to determine whether bass stocking is needed. We have found that 200 bass fry or 100 fingerlings (2 to 3 inches in length) per acre will ordinarily give satisfactory results. In no instance has seining, in conjunction with the stocking of bass, been adequate to do the job. This has been due primarily to the lack of knowledge and perseverance of the pond owner.

If a static pond contains black bullheads (A. melas) and shad (Dorosoma cepedianum), it is best to destroy the entire population and restock. When the entire population is destroyed, care should be taken to collect the fish in order to determine the approximate carrying capacity of the pond. Often, where carp (Cyprinus carpio), shad, and catfish (Ameiuridae) are dominant, the weight recovered should not be expected to represent the approximate carrying capacity for bass and bluegills. Restocking should be done on the basis of carrying capacity, according to the methods proposed by Swingle (1950).

Frequently, where ponds have been 5 acres or more in size, partial dewatering in the fall, winter, or early spring before bass spawning, has been adequate to bring the fish population into ideal balance. The partial dewatering should expose about 30 percent of the pond bottom for 1 or 2 weeks.

Ponds in which no bass or bluegill reproduction is found during the current year, or in which a light bass reproduction may have occurred and the bluegills ceased to reproduce before the usual spawning season terminated, have been classified as "out of balance." These ponds are ordinarily characterized by an abundance of Gambusia and tadpoles.

When no bass are found in an out-of-balance pond, or when bass are found along with black bullheads, shad, green sunfish (L. cyanellus), longear sunfish (L. megalotis), and pumpkinseed (L. gibbosus), it has been found best to destroy the population and restock. Where only bass and bluegills are present, partial poisoning of 25 to 30 percent of the pond in the early fall and corrective restocking with bass the following spring will ordinarily bring the pond into ideal balance within 1 year. It is essential that the fish population be inspected frequently, as sometimes it is necessary to repeat the partial poisoning one or more times to prevent the development of a dominant size group in the bluegill population.

Factors other than proper balance of the fish population must be considered if success is to be obtained. Surveys (Holloway 1951) indicate that approximately 11 percent of the ponds in the Southeast remain muddy during most of the growing season. These ponds are of little value for fish production until the silt is settled and the pond water can be maintained in a condition that permits the growth of phytoplankton. Silt may come from two sources: from the watershed, and from suspended soil particles that may be maintained for a long period by very slight wind action. When silt is introduced into the pond with the water, corrective measures may entail nothing more than a diversion of the

water and a control that permits the maintenance of the water level only when clear water is available. When silt does not come from the drainage area but is maintained by suspension of clay particles, it can be precipitated by the application of 1 or 2 tons of ground limestone per acre. Also, the clay particles can be precipitated by applying (at the rate of two or three wagonloads per acre) barnyard manure, rotten straw, or other organic matter which decays rapidly. Because of variable pond and silt conditions, it is difficult to give precise recommendations with respect to the amount of organic matter necessary to precipitate the clay particles. It has been found, however, that chemical fertilizer containing relatively large amounts of nitrogen (not ammonium sulfate or other acid-forming fertilizers) applied in conjunction with the organic materials will speed up the oxidation and will precipitate the clay particles in a shorter period of time.

Surveys (Holloway 1951) have indicated that approximately 14 percent or more of our ponds have overcrowded nonpredator populations, owing definitely to the amount of cover present. It is our opinion that at least 90 percent of the bottom area should be free of weeds or other cover if a fish population in ideal balance is to be maintained over a period of years. The maintenance of a turbid condition from plankton is the most satisfactory solution. The deepening of the shallow areas may also be necessary in a large number of ponds. Because of structural difficulties in obtaining a properly sloped bottom, it is believed that little degree of success in maintaining a properly balanced fish population can be expected from unfertilized ponds having areas less than about 2 acres in clay soils or 8 acres in sand soils. If special care is taken to excavate or increase the slope of the bottom in shallow areas, or if a plankton "bloom" is maintained to provide for at least 90 percent of the bottom being free of weeds, it is likely that success can be expected in ponds considerably smaller than the acreages just stated.

Some ponds that are constructed across small streams or in relatively large drainage areas have such large quantities of water passing through that fertilization is of no value. Many of these ponds can be improved by a simple water-control structure that will divert the water around the pond. Usually fertilization can be made effective if no more than approximately one-thirtieth of the total water volume of the pond enters the pond daily (Lawrence 1949).

Drains in ponds are desirable but not essential. They permit partial dewatering for maintenance of ideal balance of the fish population, for cleaning of bathing beaches, for dike repair and similar activities.

It is probable that one of the more important recommendations for the management of fish ponds is that the crop be harvested. Fast-growing fish ordinarily provide superior fishing and greater harvests and maintain the owner's interest in better management.

Stress should also be placed on proper fertilization for the maintenance of heavy plankton growth during the warm season. Properly fertilized ponds have greater facility to maintain ideal balance than do unfertilized ponds.

When ponds are renovated, care should be taken to see that restocking is in accordance with carrying capacity as suggested by Swingle (1950, 1951). He has demonstrated a very close relationship between theoretical and actual results when ponds are stocked according to carrying capacity.

When a pond is examined, the owner should be informed as to the course of action recommended. The renovation work should be started as soon as he has given his permission, while his interest is great and the chances of his completing all the requirements are good. A long delay in restocking after the fish population has been destroyed will almost invariably result in discouragement on the part of the owner.

LITERATURE CITED

Holloway, A. D.
1951. Evaluation of fish pond stocking policy and success in the Southeastern States. Prog. Fish-Cult. 13 (4): 171-180.

Lawrence, J. M.
1949. Construction of farm fish ponds. Ala. Poly. Inst. Circular 95, 55 pp.

Leonard, J. W.
1939. Notes on the use of derris as a fish poison. Trans. Am. Fish. Soc. 68 (1938): 269-280.

Swingle, H. S.
1950. The relationships and dynamics of balanced and unbalanced fish populations. Ala. Poly. Inst. Bull. 274, 74 pp.
1951. Experiments with various rates of stocking bluegills and largemouth bass in ponds. Trans. Am. Fish. Soc. 80 (1950): 218-230.

A PRELIMINARY REPORT ON THE CONTROL OF FUNGUS IN THE EGGS OF THE PIKE *(ESOX LUCIUS)* WITH MALACHITE GREEN

Robert W. Sharp, U. S. Fish and Wildlife Service, Minneapolis, Minnesota
Leslie H. Bennett, U. S. Fish and Wildlife Service, New London, Minnesota
Eldon C. Saeugling, U. S. Fish and Wildlife Service, Guttenberg, Iowa

THE PIKE now plays an important role as a predator in the management of the warm-water fishery of the north-central region, particularly in Minnesota, Wisconsin, Michigan, Iowa, and the Dakotas.

Artificial propagation of the pike has been attended by considerable difficulty. There are few locations from which a quantity of pike can be taken for stripping, and the percentage of hatch is usually lower than that of other commonly propagated species. Fungus has caused much trouble while the eggs are held in battery jars. In an effort to overcome this weak link in the chain of operations, it was decided to experiment with malachite green as a fungicide. For the work, the Federal hatcheries at Guttenberg, Iowa, and New London, Minnesota, were selected.

At Guttenberg, on April 17, malachite green was administered by the constant-flow siphon method (Burrows 1949) at the rate of 1:200,000 for 1 hour to 2 quarts of eggs that had been in the hatchery 3 days. Untreated eggs held higher in the battery were kept as controls. After treatment the eggs were dark green, but they cleared in 5 to 6 hours. Five days later these eggs showed a hatch of 86 percent--excellent for pike--and the untreated eggs had a percentage not noticeably different. The water at Guttenberg had a constant temperature of 52° F. In a small pool near the Mississippi River, the fry from the treated eggs reached a length of 1¼ inches before high water inundated the pool. Actually, fungus has given little trouble at Guttenberg: this phase of the experiment was designed to determine whether the drug would have any immediately noticeable ill effects on the eggs.

On April 19, when the water temperature at the New London hatchery was 40° F., approximately 5 million eggs there received the same treatment that had been used at Guttenberg. Further applications of the drug were made on April 25, April 28, May 5, and May 9. These eggs retained the deep green color much longer than the Guttenberg eggs had: some of the New London eggs showed a greenish tint throughout the experiment. The treated eggs gave a hatch of 20 percent, whereas some 360 thousand eggs used as controls gave a hatch of 10 percent. The experiment was terminated May 17, when all fry were planted. In this period the water temperature had risen gradually to 63° F.

The spring of 1950 was abnormally late, low air and water temperatures prevailing into mid-May. The low percentage of hatch at New London may have been due largely to very low temperatures when the eggs were stripped and fertilized. That the eggs taken earliest were held in the hatchery almost 40 days probably contributed to the low hatch. A nearby hatchery, utilizing eggs from the same source, had the same trouble.

From the start of the experiment, treated eggs were almost entirely free of fungus--which the very low temperatures may also have helped to check. The action of these eggs in the jars was continuous, with no clogging or matting; hence very little washing or sieving was needed. When the temperature began to rise, the eggs separated well and were easily siphoned. The fry appeared in good condition. The eggs in the control jars, however, showed considerable clogging and matting, were harder to handle, and gave a poorer hatch.

This work indicates that malachite green may be of much value in controlling fungus and reducing the labor in handling pike eggs. As further work in a more normal spring would give more conclusive results, it is planned to continue the experiment at New London in the spring of 1951.

Literature Cited

Burrows, R. E.
1949. Prophylactic treatment for control of fungus (Saprolegnia parasitica) on salmon eggs. Prog. Fish-Cult. 11 (2): 97-103.

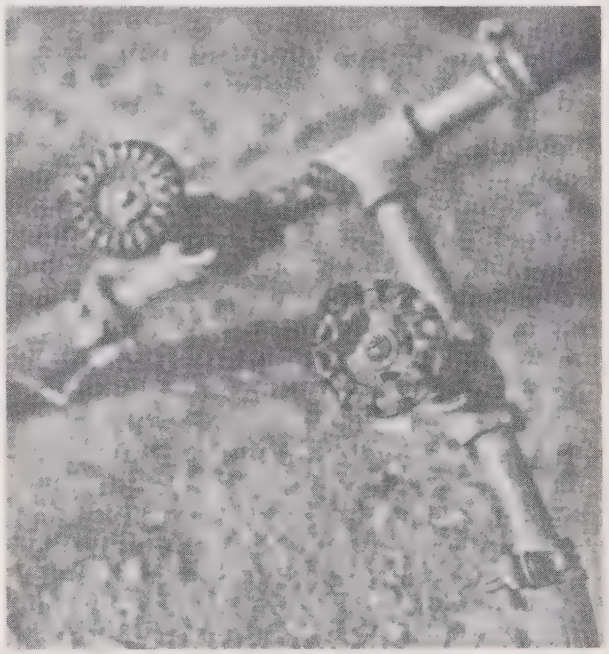
AN AID IN THE APPLICATION OF ROTENONE IN POND RECLAMATION

Howard P. Clemens
Summer Survey, Oklahoma Game and Fish Department
Oklahoma City, Oklahoma

SINCE THE ADVENT of toxins in fish management, various commercial products have reached the market. One of these is emulsifiable rotenone. In the past, 1 gallon of emulsifiable rotenone has been mixed with 3 to 10 gallons of water and then sprayed on 6 acre-feet of water. The writer wishes to suggest a method whereby rotenone and water are mixed and applied in the desired concentrations in a single step.

If much work with rotenone is contemplated, it is desirable to use a power spray. The Oklahoma Game and Fish Department has used a John Bean piston-type pump powered with a Briggs and Stratton gasoline motor having a capacity of 3 gallons per minute. This outfit is conveniently handled in a small motorboat. The intake of the pump is capped with a seed strainer to prevent debris and other foreign matter from entering and clogging the pump. Such a setup is good to pump mixtures of powdered rotenone, as well as emulsifiable rotenone. Powdered forms are more easily handled when a wetting agent is added, as Stroud has suggested (1951). A few ounces of emulsifiable rotenone will serve this purpose.

When emulsifiable rotenone and water are mixed and pumped simultaneously, a second intake is needed. This is placed at right angles to the main intake (see figure) and runs to the emulsifiable rotenone; the main intake extends over the side of the boat into the water. The construction of the right-angled joint should be noted. The nipple is threaded back so that it can be screwed as far as possible into a T joint which has been inserted into the main intake line. This leaves a very much reduced diameter at this point in the main intake. When the pump is in action, the velocity of the flow is greatly increased at the joint, the pressure is consequently decreased, and the rotenone flows in the second intake to enter the main line and become mixed with water before being pumped onto the lake. The rate of flow in the second intake may be adjusted by changing the size of the constriction. This appeared impractical in the field, but the same end was achieved by placing a valve near the T joint. The flow of rotenone is adjusted by opening or closing this valve. Another valve has been useful to govern the flow of water in the main intake. With this arrangement, it is possible to obtain sprays ranging in content from all water to all rotenone.



The main intake, extending from the water to the pump, cuts across the top of the picture. The second intake, coming from the rotenone, forms a right angle with the main.

See also:
Vestal, E. H.
1951. A new chemical apparatus. Prog. Fish-Cult. 13 (4): 219-224.

Dr. Clemens may be addressed in care of the Department of Zoological Sciences, University of Oklahoma, Norman, Oklahoma.

Flow gauges to determine the ratio of the rotenone to water were unnecessary, as the amount of the rotenone could be judged when it was pumped from a glass container marked in gallons. A little experimenting revealed the approximate openings to set the valves, and these openings were further adjusted according to the situation. The amount of rotenone to be applied to the lake was previously determined, so that it was possible to consider the amount to be applied to a given area in conjunction with the speed of the boat and then make the necessary adjustments by opening or closing the valves accordingly.

By this method emulsifiable rotenone has been applied adequately at the rate of 10 minutes per acre, although it is felt that a somewhat longer rate provides more thorough application because the amount of rotenone must be judged in accordance with the depth in any part of the lake. Generally, applications on ponds from 1 to 4 acres in size were completed in 15 to 60 minutes. With the adjustable valves and the adjustable speed of the boat, concentrations of rotenone can be increased in deeper areas and decreased proportionately in shallow areas.

When water was pumped from the lake while the boat was in motion, it was found that a negative pressure which was created around the mouth of the intake decreased considerably the rate of flow through the pump. This was overcome by affixing a bracket to hold the intake forward and into the current. This cast-iron bracket, fitted into the oarlock of the boat, held the intake in a rigid position below the surface of the water.

Literature Cited

Stroud, R. H.
1951. Use of wetting agent to facilitate pond reclamation. Prog. Fish-Cult. 13 (3): 143-145.

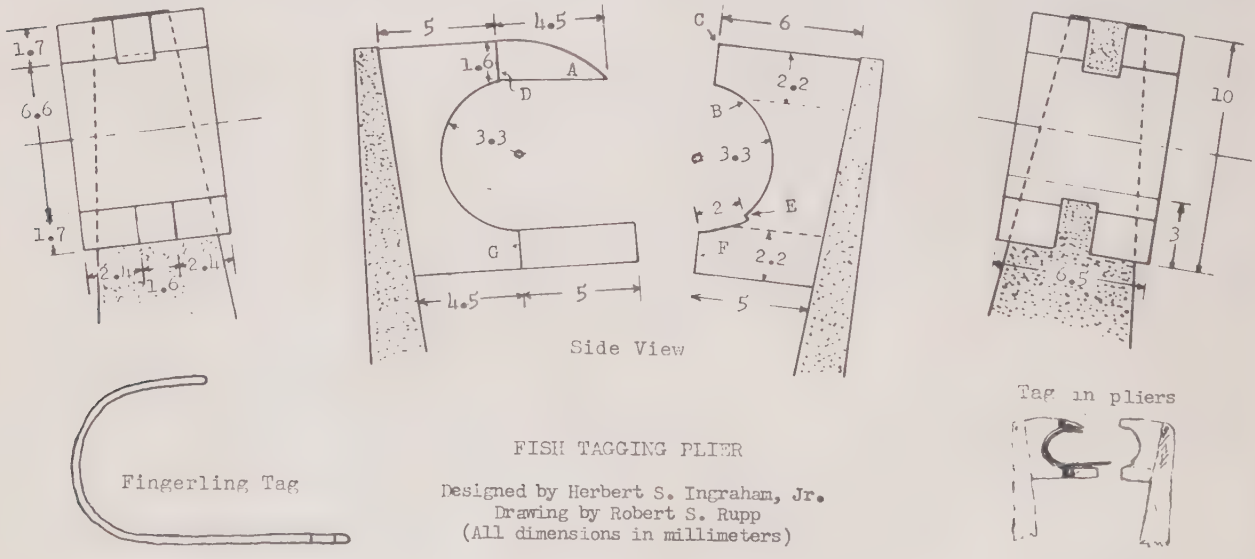
PLIERS FOR TAGGING FISH WITH FLAT FINGERLING STRAP TAGS

THESE PLIERS--reported by Robert S. Rupp, Maine Department of Inland Fisheries and Game, University of Maine, Orono--facilitate the tagging of eastern brook trout with a flat fingerling strap tag.

The tagging tool proper is made of soft steel and soldered to the jaws of a pair of electrician's pliers (stippled in figure).

The sharp stab A pierces the floor of the fish's mouth and guides the pointed end of the tag through the puncture. Groove E forces the blunt end of the tag around the curve of the tool. Passing sharp edge B, the pointed end of the tag is forced around till the pliers close. When the pliers close, shoulders F and G touch but C and D are about 1 mm. apart. Properly set, the tag is not locked: the blunt end overlaps the pointed end by 2 to 3 mm.

Mr. Rupp points out that fish so tagged need be held out of water only a few seconds.



FISH TAGGING PLIER

Designed by Herbert S. Ingraham, Jr.
Drawing by Robert S. Rupp
(All dimensions in millimeters)

REARING YOUNG SHAD IN PONDS

John C. Pearson
U. S. Fish and Wildlife Service
Washington 25, D. C.

ARTIFICIAL propagation of the American shad (Alosa sapidissima) began in 1848 and has continued each season in varying intensity to the present. In an effort to increase the commercial yield of this food fish, many billions of ripe eggs have been taken from the female fish during their migration from the sea to fresh-water spawning grounds, and these eggs have been fertilized in shallow pans and hatched in deep glass jars. Lesser billions of shad fry have been distributed in most coastal waters from Maine to Texas and successfully introduced into several streams on the Pacific coast.

It is perhaps significant that an analysis of 278 publications relating to the shad shows 47 percent devoted to phases in the life history of the fish (a comprehensive description is yet to be published), 35 percent to various aspects of artificial propagation of the species, and 18 percent to statistical matters on shad fisheries.

The actual technique of the artificial propagation of shad--from the period when ripe eggs are taken from the female fish until the helpless fry are liberated--is well advanced. A hatch of at least 85 percent of fertilized eggs can be expected at a shad hatchery. Fish-culturists have been forced, however, to liberate newly hatched young in the larval stages because of inability to hold many millions of young fish in indoor tanks and to supply them with adequate microscopic food materials.

It has been maintained that the liberation of larval shad in concentrated numbers within a limited area can result in excessive mortality as a result of predators, lack of food, and other natural factors. The ecological requirements of shad fry and post-larval young have not been determined. As a consequence, the distribution of hatchery fish has necessarily been on an unscientific basis.

As early as 1884, attempts were made at Raleigh, North Carolina, to stock enclosed ponds with shad fry in order to bring the young fish to a larger size before releasing them in natural streams. Two experiments in 1888-89 near Washington, D. C., were described in the Report of the U. S. Commissioner of Fish and Fisheries for 1888 (1892: xxviii):

> ... Nearly 3,000,000 shad fry were placed in the west pond in May, 1888. These were held in the ponds during the summer, but were not fed; on the natural food in the ponds they made rapid growth. In October, when the young were released in the Potomac River, they had attained an average length of 3 inches [76 mm.]. It was not possible to determine by actual count the number of fish liberated, but conservative estimates place the number at 50 per cent of the number of fry placed in the ponds. These results were as satisfactory as expected and indicated a new departure in fish-cultural work, which promises important consequences.
>
> In April, 1889, the same pond was stocked with about 4,000,000 shad fry. By the first of June these had attained a length of three-quarters of an inch [19 mm.], when a flood swept the entire crop into the river. Only a few hundred remained in the pond, and these, when the water was drawn off in October, had acquired a length of from 6 to 8 inches [150-200 mm.]. This illustrated in a very striking way the rapid growth made by fishes when there is an abundant supply of food, and when other conditions are favorable.

According to Worth (1910: 791), pond rearing of shad continued until 1906 with highly satisfactory results:

> Although during the past 30 years methods of shad hatching and distribution have been carried to a high degree of excellence, there remains an invitation, however, to greater effectiveness

in the possibility of extending hatchery work into rearing methods in order that shad may be liberated in the rivers in the fingerling stage with greater chance of survival.

Fifteen years later, however, Leach wrote (1925: 486):

> Owing to the difficulty in obtaining suitable ponds and the necessity of providing the ponds with a water supply that would produce sufficient natural food, the Bureau of Fisheries prefers to liberate the young shad soon after hatching on their natural spawning grounds. ... Fingerling shad are so tender that the numbers annually liberated could not be ascertained.

The decrease of the stocks of shad along the Atlantic coast has revived interest in the feasibility of holding shad fry in ponds or pools under protection until a larger and more vigorous size has been attained. An opportunity was found to make limited observations on rearing young shad in small ponds of the Fish and Wildlife Service at Edenton, North Carolina, and at Orangeburg, South Carolina, in 1937 and 1938. It seems desirable to record the results from these studies.

A quarter-acre pond, about 4 feet maximum depth, was available for experimental use at Edenton, and a somewhat larger pond and several concrete pools were used at Orangeburg. Each pond and pool was well drained and dried before being flooded and stocked with larval shad. Water was filtered through mosquito-mesh wire screens to eliminate the larger aquatic predators before shad fry were placed in the ponds and pools. Water was added to ponds to maintain a constant water level only at Edenton, but at Orangeburg a continuous flow was obtained from a natural reservoir. Overflow pipes were screened to prevent escape of fish.

In these observations it seemed possible to estimate the approximate number of fry placed in each pool or pond by taking the hatch from a volumetric quart (or fraction thereof) of shad eggs, allowing a count of 25,000 eggs to the quart. The fish were stocked as fry about 10 millimeters in length before complete absorption of the larval yolk sac.

An undetermined number of shad fry was first introduced into the pond at Edenton on May 10, 1937, to serve as possible food for young striped bass. Juvenile shad were seined from this pond at intervals until March 17, 1938, when both shad and young striped bass were removed by draining the pond. Surviving shad were transplanted to a small pond, where they were held successfully until May 5, 1938.

Young shad from this initial experiment had a length range from 32 to 45 millimeters (mode, 38 mm.) on June 11, 1937, a month after being placed in the pond. A second group, removed on October 27, had a length range from 68 to 87 millimeters (mode, 75 mm.). The young shad at the conclusion of the observations on May 5, 1938, nearly 12 months after hatching, had a length range from 92 to 125 millimeters. Table 1 gives the size range of the several lots of fish from this initial experiment.

Increment in growth was also measured by weight. Shad fry weighed but a few milligrams; at a length of 40 millimeters, fish weighed 0.5 grams; at 58 millimeters, 1.5 grams; and at 125 millimeters, 15.8 grams. Figure 1 shows the length-weight relationship of these pond-reared shad.

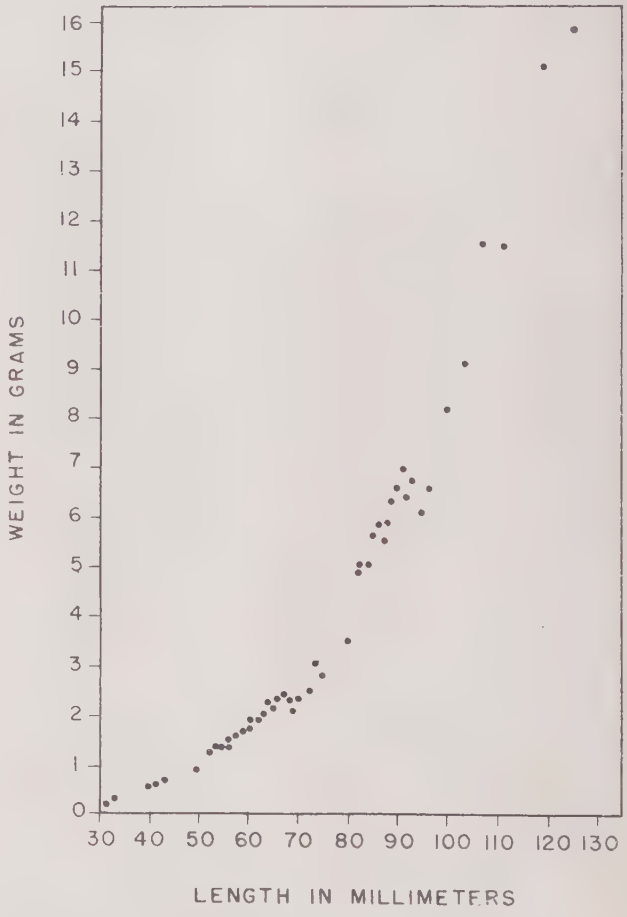


FIGURE 1.--Correlation between lengths and weights of pond-reared shad at Edenton, North Carolina, from May 10, 1937, to May 5, 1938.

TABLE 1.--Growth of young shad in ponds at Edenton, North Carolina, during 1937-38

Total length in millimeters	Shad[1] in ponds from May 10, 1937 to June 11, 1937	Aug. 20, 1937	Sept. 25, 1937	Oct. 27, 1937	Mar. 17, 1938	May 5, 1938	Mar. 30, 1938, to May 3, 1938	May 5, 1938, to Nov. 15, 1938
24-27	-	-	-	-	-	-	3	-
28-31	-	-	-	-	-	-	16	-
32-35	2	-	-	-	-	-	271	-
36-39	13	-	-	-	-	-	247	-
40-43	8	-	-	-	-	-	5	-
44-47	1	-	-	-	-	-	-	-
48-51	-	2	2	-	-	-	-	-
52-55	-	14	28	-	-	-	-	-
56-59	-	22	56	-	-	-	-	-
60-63	-	10	55	-	-	-	-	-
64-67	-	1	21	-	-	-	-	1
68-71	-	-	4	6	-	-	-	3
72-75	-	-	3	31	-	-	-	11
76-79	-	-	-	17	-	-	-	12
80-83	-	-	-	5	2	-	-	13
84-87	-	-	-	3	9	-	-	21
88-91	-	-	-	-	18	-	-	12
92-95	-	-	-	-	9	2	-	6
96-99	-	-	-	-	-	1	-	11
100-103	-	-	-	-	-	3	-	10
104-107	-	-	-	-	-	1	-	6
108-111	-	-	-	-	-	1	-	12
112-115	-	-	-	-	-	1	-	5
116-119	-	-	-	-	-	1	-	6
120-125	-	-	-	-	-	1	-	5

[1]Shad fry were approximately 10 millimeters in length when placed in ponds.

Food was given to these young shad. It consisted of finely ground sea fish, supplied three times each week. Both the young shad and the striped bass took this fish eagerly.

Approximately 20,000 shad fry were introduced into the Edenton pond on March 30, 1938, and were held until May 3, when all fish were removed and counted. The survivors totaled 6,500 fish, the length of which ranged from 24 to 41 millimeters (mode, 35 mm.). These fish were given food in the form of fine shrimp meal and occasional lots of Daphnia.

Another stocking of fish was made in the same pond on May 5, 1938, when roughly half a million fry were introduced. When drained on November 15, 1938, the pond held about 500 young shad, the length of which ranged from 66 to 125 millimeters. Apparently the shad had been well fed on ground fish and dried cereal meals. Shad seemed to consume the food freely as it floated on the surface of the water or gradually settled to the bottom. The shad fed in schools and often broke the surface of the pond during early evening in apparent attempts to catch midges and other insect life.

At Orangeburg, in 1938, four pond stockings were made with shad fry transported some 60 miles, without apparent harm, from the hatchery on the Edisto River. Pond observations at this point were made no longer than 3 months, for it appeared that growth was slower here than at Edenton, owing, presumably, to an insufficiency of natural plankton in the pond. Mortality ranged from 50 to 90 percent of the initial stocking. Table 2 presents data regarding the mortality of shad in the several ponds at Edenton and Orangeburg.

No definite information was secured to indicate the causes for the variable mortality of young shad in these enclosed ponds and pools. Fish predators were apparently absent, the water came from natural streams where wild shad occurred, and no diseased or dying fish were ever observed.

TABLE 2.--Mortality of young shad reared in ponds at Edenton, North Carolina, and Orangeburg, South Carolina, during 1938

Place and duration of experiment	Number of fry planted	Number of shad reared	Percentage mortality
Edenton			
Mar. 30 - May 3	20,000	6,500	65
May 5 - Nov. 15	500,000	500	99
Orangeburg			
Apr. 4 - May 18	6,000	2,500	58
Apr. 18 - June 1	5,000	1,500	70
Apr. 23 - June 1	10,000	5,000	50
Apr. 7-23 - Aug. 16	42,000	4,000	90

Possibly a contributing factor in the death of the young shad may lie in the artificial handling of ova, sperm, incubating eggs, and fry: perhaps this tends to produce constitutionally weak fish which are unable to survive when natural feeding must be started. It is known that a high mortality of shad fry often occurs at hatcheries despite a low mortality of incubating eggs. In such instances, lack of food or the presence of predators cannot be held responsible for the death of larval shad.

Availability of suitable food appears to be an important factor in the survival of confined young shad. Planktonic food must be present in sufficient abundance, with respect to time and place, to meet the heavy demands of the young fish when they first seek natural food after absorption of the yolk sac. This requirement holds true when the shad fry are liberated in natural streams or placed in ponds, as well as under natural spawning conditions.

It is evident that additional information regarding the food requirements of young shad must be secured before sound judgment can be made on the feasibility of rearing any significant quantities of shad in ponds for restocking natural waters. It is known that limited numbers of fish can be reared at least to fingerling size in small ponds where the fish are readily accessible. The lower mortality rates seem to occur when the fish are held about a month and have attained a length of about 25 millimeters. These fish are active and relatively well able to care for themselves in natural waters.

Literature Cited

Leach, G. C.
1925. Artificial propagation of shad. App. VIII, Report of U. S. Commissioner of Fisheries, 1924. pp. 459-486.

Worth, S. G.
1910. Possible expansion of shad-hatchery work. Bull. Bur. Fish. 28 (pt. 2): 789-793.

U. S. Commissioner of Fish and Fisheries.
1892. Report, U. S. Commissioner of Fish and Fisheries, 1888. pp. ix-cxxi.

METHOD OF SECTIONING CARP SPINES FOR GROWTH STUDIES

THIS SAW--reported by Thomas S. English, Iowa Cooperative Fisheries Research Unit, Ames, Iowa--has greatly reduced the time required to make cross sections of spines for growth studies of the carp (*Cyprinus carpio*).

The dental separating saw has a circular blade (0.75 inch in diameter) mounted in a mandrel held by a chuck on the shaft of the electric motor (here, a dental lathe). A rheostat controls the speed of the lathe, but its maximum (rated at 3400 r.p.m.) has been most satisfactory. A vise-held wood block, set very close and parallel to the blade, is crossed by a sliding wood L. The operator uses the L to guide the spine into the blade.

Small spines, hard to handle and likely to shatter during sectioning, are mounted in bioplastic before being sectioned. Such sections are more easily handled during examination with the microprojector.

Though the thinnest sections gave the best results, sections as thick as 0.5 mm. were satisfactory. Translucency of the sections was improved by soaking them in xylene during examination.

From Project 39, Iowa Cooperative Fisheries Research Unit, sponsored by the Iowa State Conservation Commission and the Industrial Science Research Institute of Iowa State College.

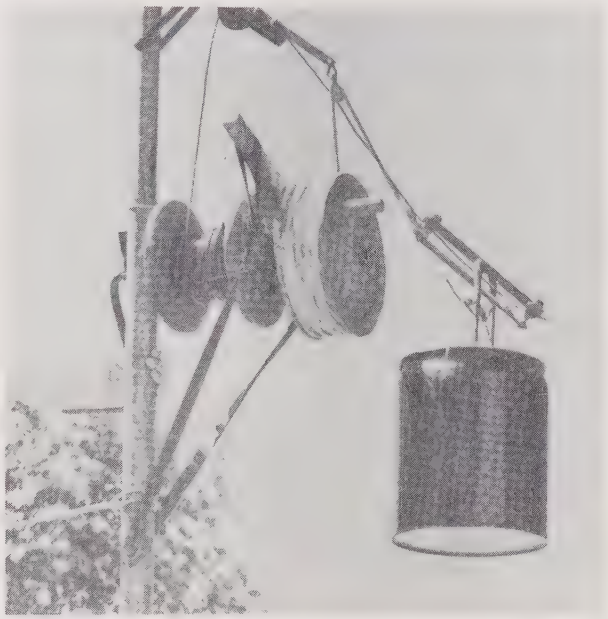
TROUT ON A TROLLEY IN OREGON

Chris C. Jensen
Oregon State Game Commission
Portland, Oregon

THE TROUT FISHERY of the McKenzie River in Oregon is subject to intensive management, part of which is related to research concerned with the measurement of the effects of various types of fish planting methods. To determine the effect of a wide scatter of planted trout, the author developed a method by which it is possible to place fish in the river at many locations generally inaccessible by planting boat and difficult to reach by the "bucket and leg-work" method even though a road parallels the river for much of its length.

The method developed involves a device which takes much of the work and many of the hazards out of fish liberations along the river. Known as a trout trolley and costing about $65, the apparatus allows the fish liberator to reach easily areas up to a distance of 200 feet that heretofore have been bypassed because of rough terrain.

A winch with two independently operating wooden drums has been installed at one end of a 2-inch pipe, 5 feet in length. The diameters of the drums are 6 inches and 10 inches, respectively. On the other end of the pipe is a removable floor flange which is used to fasten the pipe to the bed of the liberation truck. The placement of the flange will depend on the type of truck used, but a forward position is satisfactory. Another pipe, about 5 feet long and small enough in diameter to slide easily into the larger pipe, serves as a telescoping mast which can be raised at will and turns freely. The mast is held at the desired level with a large pin which is inserted through holes in the pipes. Two pulleys are fastened with strap iron to the top of the mast. The pulley nearer the mast serves as a guide for the flexible ¼-inch cable which runs up from the first drum on the larger pipe. The other pulley guides the small rope which comes up from the second drum. The small rope is fastened to a two-wheel trolley, made of two sash pulleys and some inch strap iron, which operates on the cable. An iron hook is fastened to the running end of the cable.



In operation, one man takes the hook in hand, walks down the bank to the stream, and takes a turn around a tree or some solid object. The second man tightens the cable with the hand winch. The man on the liberation truck dips out the fish with a 5-gallon bucket or a deep rubber-bottomed dip net, hooks the container onto the trolley, and rapidly lowers the fish to the streamside man. The latter liberates the fish and fastens the empty container to the trolley for the return trip to the truck. A friction brake operating on the larger drum controls the speed of the trolley as it travels down the cable. Fish are necessarily transferred dry when the net is used; however, because of the speed of the operation, it is believed that they suffer no ill effects.

The apparatus, installed on a 1-ton pickup with a portable liberation tank, has been used successfully in 1950-51 on the McKenzie River.

One word of caution: Don't drive under low wires or archways unless the apparatus is at half mast or lower!

REVIEWS

HETEROGENEOUS STIMULUS SUMMATION IN THE RELEASE OF SPAWNING ACTIVITIES IN FISH

By Eric Fabricius. Institute for Freshwater Research, Drottningholm, Sweden Report 31: 57-99. 1950.

The relationship between water temperature and fish spawning has long been recognized by fish-culturists. It has also been recognized that the time of spawning sometimes does not show the usual relationship with temperature. Eric Fabricius discusses some phenomena which help to explain these discrepancies.

Various investigators have shown that instinctive actions, such as spawning, are controlled by a "releasing mechanism" in the central nervous system.1/ This mechanism starts the action when the animal receives certain stimuli, through vision, scent, sound, taste, or physical contact. It may be that a single stimulus is needed to start an action. In most actions, particularly those concerned with spawning, a series of stimuli are needed to release the action; otherwise, the action might be initiated at inappropriate times.

In connection with spawning there are indications that delay of spawning may "lower the threshold" or make less external stimulus necessary. The hormones secreted by the sexual organs probably apply internal stimuli until the external stimuli needed to start the action are greatly reduced, or it may even require no observable external stimulus if the action is delayed too long.

Spawning of pike (Esox lucius L.) was studied at two sites at one Swedish lake. At both sites the water rose between May 7 and 31, 1949, to cover the following zones in sequence: (1) no vegetation, (2) sparse horsetail (Equisetum), (3) sedge, (4) willow, (5) birch, and (6) spruce. At the first site, the water temperature reached 8° C. (about double the usual spawning temperature for northern pike) before the water got into the first vegetated zone, the horsetail. No spawning occurred until the visual stimulus from the vegetation was added to the temperature stimulation. At the second site, the water temperature remained constant at 3° C. until May 25, after most of the spawning was completed. The fish at this site spawned one week later than those at the first site. Apparently the continued stimulus from the vegetation and the internal stimuli were sufficient to initiate spawning even without the usual temperature rise. The type of vegetation did not seem significant as a stimulus, for spawning occurred in all zones. Pike concentrated near the spawning sites before there was any noticeable change in the water temperature. It is believed that this assembling action was initiated in response to internal stimuli from the increased gonad action and probably to the lengthening of the days. No correlation between sunshine and spawning activity of the northern pike was noted, as reported by McNamara in 1937, but sunshine may be a sign stimulus in some situations.

Studies on several species of the whitefish (Coregonus) in a series of lakes and streams indicated that temperature and bottom types were also important release stimuli in these species. The "storsik," a large bottom-feeding whitefish, spawned in running or still water from the end of September to the last of February. At each site, however, spawning was completed in 3 to 4 weeks. Spawning occurred on rubblestone, gravel, or coarse sand bottom at depths of 1 to 30 feet. Spawning occurred at temperatures from 0.5° to 4.0° C. (33° - 39° F.), and the differences in spawning time appeared to be due to differences in the cooling of the water at the various sites. The "asp" and the "sill," two smaller plankton-feeding whitefish, spawn in deeper water where temperatures are more uniform, and the spawning season did not vary much at the different sites. The "asp" spawns

---

1/For further information on this subject, the reader is referred to:

Tinbergen, N. 1948. Social releasers and the experimental method required for their study. Wilson Bull. 60: 6-51.

Noble, G. K. 1938. Sexual selection among fishes. Biol. Reviews (Cambridge) 13: 133-158.

on shingle or gravel bottom with a steep slope, at depths of 9 to 95 feet and at a temperature of 2.1° C. (about 36° F.). The "sill" spawns on flat bottoms of gravel and soft sediments at depths of 6 to more than 50 feet and at temperatures of 1.8° C. (about 35° F.).

Changing the water levels in a lake in which char (Salmo alpinus L.) lived changed their spawning habits, but these changes could be explained on the basis of the summation of the proper release stimuli. Before the changes, the char spawned only in the lake and only at depths of 3 to 6 feet. In 1948 a regulatory dam raised the water level about 25 feet. That fall and in the succeeding spawning seasons, char spawned in the tributary streams and in the lake at depths ranging from 3 to more than 30 feet. Prior to the water-level change, the char had been excluded from the streams by waterfalls near the mouths. The char had spawned only at depths of 3 to 6 feet because these were the only available areas of gravel. After new areas were flooded, gravel areas--but still rather restricted areas--were available at several depths. The depth at which these char spawned and the fact that they spawned only in the lake before the changes, were therefore not characteristics of this race of trout. Such characteristics may be typical of some races or species, but further study is usually needed to determine whether these spawning traits are racial or just circumstances due to the environment. Because different combinations of stimuli may result in releasing the spawning activity, in different seasons or at different sites, it is often difficult to determine the effect of any one stimulus, such as water temperature.

Kenneth D. Carlander
Iowa State College
Ames, Iowa

FERTILITY OF CHAR (Salmo alpinus L.) IN THE FOXÅLVEN WATER SYSTEM, SWEDEN
and
SUPPLEMENT TO THE FERTILITY OF CHAR (Salmo alpinus L.) IN FOXÅLVEN WATER SYSTEM, SWEDEN

By A. Määr. Institute for Freshwater Research, Drottningholm, Sweden
Report 29: 57-70. 1949. Report 30: 127-136. 1950.

NATURAL SELECTION AND EGG NUMBER IN FISH

By G. Svärdson. Institute for Freshwater Research, Drottningholm, Sweden
Report 29: 115-122. 1949.

It is common knowledge that fish produce large numbers of eggs. Svärdson and Määr present some ideas upon the factors which control this fecundity. The number of eggs that a species of a fish characteristically develops is an adaptation, subject to evolution and natural selection. If two female fish produce eggs of the same quality but in different quantity and if these eggs are laid under the same conditions, the female which produced the more eggs will be represented by the more offspring in the next generation. If her ability to produce more eggs was genetically based, there should be a rather rapid and steady increase in the numbers of eggs produced per female from generation to generation. The more severe the selection pressure (or the greater the mortality), the more rapid would be the increase in the fecundity of the females. The egg number does not increase each generation, however, and there must be a selective pressure for decreased numbers of eggs which counterbalances the selection for increased numbers.

From a theoretical point of view, Svärdson postulates four ways in which there might be a selection for decreased numbers:

1. Production of too many eggs might reduce the vitality of the mother and reduce her survival value.
2. There may be an anatomical and physiological limit to the female's capacity to produce eggs.
3. In the case of species which care for eggs or fry, the rate of survival in the nest or brood may decrease as the numbers of eggs increase, owing to a limit in the number the parent can care for or protect.
4. There may be a premium on large eggs, and several studies have shown that the larger the eggs, the fewer a female of a given size can produce.

For many species of fish, the final hypothesis is the only one on which supporting evidence is available. It has frequently been indicated that larger eggs produce faster-growing fish, at least during the early stages in life.

In lakes initially stocked with a species, the survival of the young fish is characteristically much higher than when fish are stocked in a lake already well supplied with that species. Even when predatory species are originally present, the survival of stocked fry of another species may be very high, indicating that predation is probably not the principal difference in the survival rates. Competition, among the fry and fingerlings of the same species, appears to be the more important factor. Under such conditions, the advantages of large eggs and large, fast-growing fry would be most pronounced. Thus Svärdson indicates that where competition is greatest, the tendency would be to produce larger, but fewer, eggs. When the intraspecific competition is lowered by overfishing, a rise in egg numbers would be expected.

The selection for larger fry also may have an effect in setting the spawning period. When some mutant fish spawn earlier than the average, their offspring will have a size advantage when the others hatch, provided that there is food enough for their survival at the earlier date. In this way the spawning period is determined by the counterbalance between early spawning and the risk of unsuitable conditions at the earlier period.

It has been shown that average egg numbers for trout increase with altitude. Svärdson points out that the environmental factors might well be more important than intraspecific competition as the borderline of existence is approached, and that the increased fecundity of trout might be associated with the more vigorous environment.

Määr, in a study of the fecundity of char, supports several of Svärdson's concepts. Määr found that the populations of char spawning at various sites in the Foxälven water system could be distinguished on the basis of length distribution and egg numbers per female. Near the center of the distribution of char in the water system, the females produced fewer, but larger, eggs than did the populations spawning both upstream and downstream from the areas where char were more abundant. In the areas near the edge of the range, the intraspecific competition was decreased and therefore the advantages of large eggs were less significant. The selection was, therefore, for greater numbers of eggs.

Kenneth D. Carlander
Iowa State College
Ames, Iowa

CLEARING HOUSE

A fishway that shad ascend.--G. B. Collins.
Spec. Sci. Rept., Fisheries
No. 65. 17 pp. July 1951.
(processed)

A survey of former shad streams in Maine.--C. C. Taylor.
Spec. Sci. Rept., Fisheries
No. 66. 29 pp. August 1951.
(processed)
Fish and Wildlife Service
Interior Building
Washington 25, D. C.

Utilizing stock tanks and farm ponds for fish.--Marion Toole.
Bull. 24. 53 pp. rev. 1950.
Texas Game, Fish and Oyster Commission, Austin, Texas

Decline of the lake trout fishery in Lak Michigan.--Ralph Hile, P. H. Eschmeyer and G. F. Lunger.
Fish. Bull. 60 (Fish. Bull., Fish and Wildlife Service, 52: 77-95.) 1951. 20¢.
Superintendent of Documents
Government Printing Office
Washington 25, D. C.

Nutrition of trout: Cortland Hatchery Repor No. 19 for the year 1950.--A. M. Phillips Jr.; D. R. Brockway; A. J. J. Kolb; J. M Maxwell; et al.
Fish. Res. Bull. 14.
24 pp. 1951. 10¢.
New York Conservation Department
Albany 7, New York